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Session 1: Optimization

chair: Jason Papathanasiou

Robust Optimization Approaches for Portfolio Selection: A computational and comparative analysis with statistical guarantees

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Abstract

The field of portfolio selection is an active research topic, which combines elements and methodologies from various fields, such as optimization, decision analysis, risk management, data science, forecasting, etc. The modeling and treatment of deep uncertainties for future asset returns is a major issue for the success of analytical portfolio selection models. Recently, robust optimization (RO) models have attracted a lot of interest in this area. RO provides a computationally tractable framework for portfolio optimization based on relatively general assumptions on the probability distributions of the uncertain risk parameters. Thus, RO extends the framework of traditional linear and non-linear models (e.g., the well-known mean-variance model), incorporating uncertainty through a formal and analytical approach into the modeling process. Robust counterparts of existing models can be considered as worst-case re-formulations as far as deviations of the uncertain parameters from their nominal values are concerned. Although several RO models have been proposed in the literature focusing on various risk measures and different types of uncertainty sets about asset returns, analytical empirical assessments of their performance have not been performed comprehensively. The objective of this study is to fill in this gap in the literature. More specifically, we consider different types of RO models based on popular risk measures and conduct an extensive comparative analysis of their performance using data from the US market during the period 2005-2016. For the analysis, three different robust versions of the mean-variance model are considered, together with two other robust models for conditional value-at-risk and the omega ratio. The robust versions are compared against standard (non-robust) models through various portfolio performance metrics, focusing on out-of-sample results. The analysis is based on a rolling window approach. To convey constructive information, additional experiments are performed to evaluate the statistical properties inferred with the RO framework.

KEYWORDS

portfolio; robust optimization; investment; out-of-sample performance; risk measures ; statistical tests

INTRODUCTION

A research area that has grown rapidly over the past decades is financial engineering. Financial engineering is a multidisciplinary field involving financial theory, the tools of mathematics, and the practice of programming. One popular field of research in this area concerns the portfolio selection and management. The seminal approach of Markowitz during the 1950s was the cornerstone in this area and altered the philosophy in the financial domain. Although the mean-variance model is extensively employed by practitioners, it has several impractical aspects. To begin with, Markowitz's framework considers the first two moments of the distribution and therefore implies that the underlying asset returns are normally distributed, Markowitz (1952). Robust models include methods to improve the accuracy of inputs and to apply robust optimization framework to portfolio optimization. Although many researchers have conducted out-of-sample performance tests to contrast the classical mean-variance model and robust models, there has not been a dominating conclusion to the performance of such approaches, Kim et al. (2013). In this paper we will present a thorough investigation between the efficiency of classical portfolio approaches i.e., (Value at Risk, Conditional Value at Risk, etc.) along with their robust counterparts. In the past, various works have focused on portfolio optimization models. Recently, there seems to be an inclination towards the use of intelligent algorithms, addressing the loss and aversion balance, coupled with uncertainty, Grishina et al. (2016). As we examine comparative analysis performed on portfolio selection problems, we also refer to Xidonas and Mavrotas (2014), that addresses non-convex portfolio optimization, using the index S&P 500. Goal programming can be seen as an alternative way of treating

portfolios, in which a mean-variance skewness kurtosis entropy model is shown, Aksarayli and Pala (2018), in which the experiments were carried out on the basis of a rolling horizon approach.

Our main contribution lies in providing an extensive analysis for evaluating robust optimization techniques under different architectures, based on different performance measures. We are particularly interested in investigating the efficiency of the models considered, in periods, which could behave out-of-the-box, by incorporating a high level of turmoil, such as the year 2008, where the global financial crisis took place. This incorporation could result in an additional degree of complexity, which we should account for throughout the paper, rendering the corresponding results more representative. At the same time, we compared the performance of the employed robust framework with the non-robust variants of each respective model, with respect to certain performance indicators. By doing so, we opt for a concrete understanding in terms of the achieved superiority of robust models as opposed to their non-robust equivalents.

PORTFOLIO SELECTION ANALYSIS

As a first step towards the realization of the models used throughout this paper, we stress some classical portfolio optimization models, which as a first step do not take into account the uncertainty affiliated within their inner dynamics. For any given level of expected return, a rational investor would choose the portfolio with minimum variance from the set of all possible portfolios. The set of all possible portfolios that can be constructed is called the *feasible set*. Minimum variance portfolios are called *mean-variance efficient portfolios*. The set of all mean-variance efficient portfolios, for different desired levels of expected return, is called the *efficient frontier*.

METHODOLOGY

We evaluate the in-sample and out-of-sample performance of the employed models, across one empirical dataset of daily returns, using certain performance criteria. To assess the magnitude of the potential gains that can be realized by an investor, it is necessary to analyze the *out-of-sample* performance of the strategies from the optimizing models. Afterward, the performance of the non-robust portfolio models would be contradicted with their robust variants. The non-robust models considered along with their robust expressions are shown in Table 1.

Table 1: List of asset-allocation models

Model Classification	Abbreviation
Non-Robust Models	
Mean-Variance	(Mv)
Omega Ratio	(OR)
CVaR	(CVaR)
Robust Models	
Robust Mean Variance	(MvBU)
Robust Ellipsoidal	(MvEU)
Robust Bi-Objective	(RB)
Worst-case Omega	(WCOR)
Worst-case CVaR	(WCVaR)

We perform simulations based on historical data publicly available from Yahoo Finance, acquired from time series for the index S&P 500 spanning the period from January 1, 2005, to December 31, 2016. S&P 500 is the most common equity index and is often used as a benchmark for the developed equities, Kapsos et al. (2014). This dataset comprises approximately 500 stocks from the New York market. For this analysis, we use 20 portfolios to optimize. While the performance of portfolio optimization models may depend on the conditions prevailing in the financial markets, the period of the analysis allows the consideration of periods characterized by different patterns. This intriguing period would be a challenging test-bed for the framework considered, since it incorporates the year, where the global financial crisis took place in 2008, Reavis (2012), leading to a highly unpredictable factor in terms of the performance of the models considered. Inspired by the procedure proposed by Gilli and Schumann (2011), we conduct rolling-window backtests. From the historical window in every period, the simulation incorporates four quarters of each year (in-sample) and one quarter (out-of-sample), where the quarters do not necessarily originate from the beginning of each year; each run could start from the middle of each year, but the spanning period will always be one year. This rolling-

window approach enables the testing of the models under different market conditions, including cases where portfolios are constructed during a bullish market and tested on a bearish environment (and vice versa). Based on the outputs acquired from the in-sample period, the simulation uses these data to evaluate the efficiency of the portfolios created in the out-of-sample period. Our goal is to study the performance of the aforementioned models based on the data acquired from the international portfolio market of New York.

RESULTS

We will evaluate the performance of both the non-robust and the robust models for a series of performance indicators. In terms of the diversification index, we can see in Table 2 that among the three extensions of the mean-variance framework in the robust sense, comprising (MvBU), (MvEU) and (RB), only (MvBU) performs worse than the (Mv). Moreover, (OR) and (CVaR) attain a lower level of diversification compared to their robust variants (WCOR),(WCVaR), respectively. We can also detect that for the three robust models (MvBU), (MvEU) and (RB) there is a significant increase between the number of stocks in the portfolios, compared to the non-robust model (Mv). This isn't the case, however with the remaining two robust models (WCOR),(WCVaR). More specifically, the portfolios developed with the (WCOR) have a slightly lower number of assets compared to the portfolios developed with (OR). On the other hand, for this metric explicitly, we note that (CVaR) performs slightly better compared to the robust counterpart (WCVaR).

A general finding suggests that with the exception of (MvBU), each other robust model achieves systematically a lower turnover than its non-robust counterpart. Moreover, it is interesting to note a peak value for the robust mean-variance model somewhere around the 16th period of the simulation, which coincides with the year 2008, when the collapse of the U.S. housing market triggered the financial crisis, leading to dramatic plunge of major stock markets (Reavis, 2012). This is an indicator, that the simulation procedure can accurately replicate the incident of the financial crisis carried out in 2008.

Taking a look at the mean return from each model, we can realize that for the non-robust models, there is a difference between the values obtained for the in-sample data and for the out-of-sample data. Overall, the (OR) model does perform in a superior manner compared to (Mv) and (CVaR) for each performance indicator illustrated in Table 2, in terms of the out-of-sample data (except the mean return, where these models perform equally). Regarding the Conditional Value at Risk metric, three different confidence levels are employed. We start with a 90% confidence level in the first case and then we augment it to 95% in the second case reaching 99% in the third case. We notice, that even though the (CVaR) model should possess the smallest value for each one of the different confidence levels imposed, for the Conditional Value at Risk metric, this model does attain nevertheless the highest value among (Mv) and (OR) for a 99% confidence level, in terms of the out-of-sample data, that being 0.0302 (for CVaR model) compared to 0.0247 (for (Mv) models) and 0.0285 (for (OR) model). Furthermore, we can detect that the results we get for the standard deviation and for the Conditional Value at Risk (along with 3 confidence levels) are quite consistent with respect to the in-sample data compared to the out-of-sample data, for these non-robust models, with almost indistinguishable discrepancies. The detailed results for the non-robust models are shown in Table 3.

In terms of the robust variants for the computation of mean-return in Table 4, all models perform better in-sample rather than out-of-sample. Among the in-sample Sharpe ratios for the robust models at hand, (MvBU) attains the highest value (0.4027) for the in-sample data, implying that this model can perform decently within the bounds of the *box uncertainty*. We see, that the Conditional Value at Risk metric we get explicitly from the optimization of (WCVaR) doesn't attain the smallest value among the robust models for none of the confidence levels considered, as far as the in-sample data are concerned. An instance, which comes as a surprise is, that for the out-of-sample data, (WCVaR) model does acquire the second worst value (after the (RB) model) in terms of Conditional Value at Risk metric among the robust models for each of the confidence levels mentioned. This behaviour could be attributed to the fact, that the value of (WCVaR) is actually the average of the 20 portfolios considered, where each one corresponds to a certain risk and return, depending on its location in the efficient frontier curve. Indeed, one portfolio does minimize the risk, but since we are interested in the average form of the risk, it is possible to get an inferior value for the Conditional Value at Risk metric for model (WCVaR) in comparison with the other robust models. Additionally, another factor which could cause this behaviour lies in the fact of the step imposed for each robust model, to construct the efficient frontier. With the exception of (WCOR), which represents a single portfolio, every other robust model utilized an alternative step to designate the efficient frontier. Similarly, (WCOR) does acquire the worst value as far as the Omega ratio metric is concerned for the out-of-sample data, among the rest of the robust models. The fact, in this case, is that as was mentioned before, (WCOR) poses a sole portfolio, so no average form was taken and nevertheless, it attained the smallest value, it being (1.2351) in comparison with the other robust models, which used an average form to account

for the Omega ratio metric. Another finding which is suggested by the results shown in Table 4 is that (RB) performs quite consistently, not only for the in-sample data but also for the out-of-sample data, as well.

Table 2: Descriptive statistics for the composition of the portfolios

Metrics	(Mv)	(OR)	(CVaR)	(MvBU)	(MvEU)	(RB)	(WCOR)	(WCVaR)
Assets in portfolio	17.1591	16.9773	11.5375	80.4636	147.8466	363.1795	15.8182	12.7602
Diversification index	0.2244	0.1755	0.2571	0.3303	0.0618	0.0029	0.1691	0.2020
Turnover	0.1540	0.1489	0.1791	0.3809	0.0709	0.00139	0.1466	0.1667

Table 3: Performance metrics for the non-robust models

	(Mv)	(OR)	(CVaR)
Mean return (in-sample)	0.0017	0.0017	0.0018
Mean return (out-of-sample)	0.0003	0.0003	0.0003
Standard deviation (in-sample)	0.0093	0.0080	0.0101
Standard deviation (out-of-sample)	0.0105	0.0093	0.0112
Sharpe ratio (in-sample)	0.2119	0.2593	0.2032
Sharpe ration (out-of-sample)	0.0649	0.0694	0.5084
Sortino ratio (in-sample)	0.4064	0.5148	0.4224
Sortino ratio (out-of-sample)	0.1331	0.1391	0.1218
Omega ratio (in-sample)	1.7797	2.0802	1.7288
Omega ratio (out-of-sample)	1.2488	1.2624	1.2262
90 % CVaR (in-sample) %	0.0150	0.0127	0.0153
90 % CVaR (out-of-sample) %	0.0185	0.0161	0.0197
95 % CVaR (in-sample) %	0.0188	0.0161	0.0182
95 % CVaR (out-of-sample) %	0.0226	0.0196	0.0239
99 % CVaR (in-sample) %	0.0271	0.0229	0.0268
99 % CVaR (out-of-sample) %	0.0285	0.0247	0.0302

Table 4: Performance metrics for the robust models

	(MvBU)	(MvEU)	(RB)	(WCOR)	(WCVaR)
Mean return (in-sample)	0.0013	0.0007	0.0007	0.0016	0.0015
Mean return (out-of-sample)	0.0003	0.0004	0.0005	0.0002	0.0004
Standard deviation (in-sample)	0.0054	0.0067	0.0114	0.0086	0.0091
Standard deviation (out-of-sample)	0.0086	0.0073	0.0111	0.0093	0.0099
Sharpe ratio (in-sample)	0.4027	0.1268	0.0772	0.2396	0.1952
Sharpe ration (out-of-sample)	0.0661	0.0880	0.0704	0.0601	0.0702
Sortino ratio (in-sample)	-	0.2229	0.1312	0.4733	0.4002
Sortino ratio (out-of-sample)	0.1378	0.1723	0.1303	0.1243	0.1418
Omega ratio (in-sample)	-	1.4210	1.2413	1.9592	1.6885
Omega ratio (out-of-sample)	1.2633	1.3205	1.2507	1.2351	1.2667
90 % CVaR (in-sample) %	0.0083	0.0119	0.0210	0.0137	0.0143
90 % CVaR (out-of-sample) %	0.0149	0.0128	0.0197	0.0165	0.0173
95 % CVaR (in-sample) %	0.0104	0.0149	0.0260	0.0172	0.0170
95 % CVaR (out-of-sample) %	0.0181	0.0155	0.0236	0.0199	0.0211
99 % CVaR (in-sample) %	0.0151	0.0220	0.0367	0.0243	0.0224
99 % CVaR (out-of-sample) %	0.0230	0.0194	0.0289	0.0253	0.0264

CONCLUSIONS

Although robust models decrease the sensitivity in parameter estimation errors, it is not a trivial task to measure how successfully the proposed models achieve their goals under practical settings. The verdict from this comparison between robust and non-robust models is, that there is an improvement displayed in the results we get, without that being universal. Robust optimization models cannot always cope with the uncertainty in a convincing manner. In general, the out-of-sample results with respect to the robust models are superior to those we get for the non-robust models.

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Water resources management optimization based on tradable water permits

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Abstract

It is commonly accepted that fresh water is a key commodity for the proper and effective functioning of modern societies. This fact combined with the limited availability of water, the increasing competition among its users and mainly the publication of the Directive 2000/60/EC by the European Union which recognizes water not only as a fundamental social good but also as an economic good, has created modern challenges relating to the management of that natural resource. Thus, research attention has recently focused on the search of economic tools and on the investigation of the possibilities of applying those tools to water resources management in order to address the challenges mentioned above. Tradable water permits are one of those tools. At the same time, recent studies show that even though the application of operational research models, and especially of optimization models which is the most widespread technique of that, is quite prevalent in water resources management problems, studies that address modern challenges are still absent from the relevant literature. Those challenges require integrated solutions that combine the minimum cost for the organization that manages the water resources with the maximum benefit for their users and of course with the rational and sustainable use of the resources. The present work falls into that framework, since it introduces an optimization model based on the tool of tradable water permits which attempts to ensure the optimal allocation of water quantities among competing users, incorporating economic and environmental parameters into that.

KEYWORDS

water resources management, tradable permits, optimization, competing users.

INTRODUCTION

In recent years the rapid economic growth and the simultaneous population explosion observed have created problems in many areas of the world related to water shortage (Borghesi, 2013). As cited by Hadjigeorgalis (2009), the 2006 United Nations Human Development Report (UNHDR) points out that this global water-related crisis is not the product of some natural defect of the resource itself but the result of a series of unsuccessful public policies aimed at managing it. The publication of the Directive 2000/60 EC by the European Union, which on the merits recognises water not only as a fundamental social good but also as an economic good paved the way for a new planning for water, since it allows the use of economic tools with the intention of making water use more efficient. Tradable water permits, i.e. a water rights allocation system that offers the possibility of exchanging these rights for money (Latinopoulos, 2016) are one of those tools, which is considered particularly useful because it increases the economic productivity of water by encouraging the movement of water quantities to users who can attribute to them as much value as possible (Zeng et al., 2014; Latinopoulos and Sartzetakis, 2014). Thus, several relevant studies have developed optimization models based on the concept of tradable water permits with representatives that of Latinopoulos and Sartzetakis (2014) and that of McKinney and Davitsky (2006). Most of these works deal only with users who consume water for irrigation purposes. Thus, they do not take into account the intense competition among the various users of water, that makes it necessary to seek integrated solutions that consider the needs of all the stakeholders involved. The present work falls into that framework, since it introduces an optimisation model based on tradable water permits through which it is attempted to distribute water to competitive users. This model incorporates economic and environmental parameters and its main objective is to maximise the total net benefit of the society which results as the sum of the benefits of individual users.

METHODOLOGY

Before presenting the proposed model what should initially be noted is that the operation of each system based on tradable water permits requires an initial allocation of water quantities for consumption or use more generally to users which takes place at the beginning of the time period considered (which is one year for the proposed model) and can be carried out by various methods. In this paper it is considered that the initial allocation of water rights to users is for a monetary fee, so each user $i = 1 \dots n$ receives a water permit of quantity $q_i, i = 1 \dots n$ against price $p_i, i = 1 \dots n$, which price is common to all users.

In order to form the proposed model, three different categories of users are considered: (a) domestic use, (b) agricultural use and (c) industrial use. These categories are henceforward symbolized by $i = 1, i = 2, i = 3$ respectively. The objective of the proposed model is to maximise the total net benefit of the society NB_{tot} , which results from the use of water and equals the sum of each category's net benefit NB_i . Hence, since the optimization model formed follows the standard form of these models, i.e. it has an objective function and constraints, its objective function is as follows:

$$\max NB_{tot} = \sum_{i=1}^3 NB_i \quad (1)$$

In order to calculate the net benefit NB_i for each category of users the benefit they derive from the water consumption and the cost of obtaining the corresponding water rights need to be considered as well as the costs for the additional water quantities they can purchase from the others or the revenues from the water quantities they can sell to the others due to the implementation of tradable water permits. It is important to note that the transactions of water quantities are allowed only between the three categories of users each of whom is represented by an organisation authorised to negotiate on their behalf. The model does not take into account any transactions between users belonging to the same category and it considers that the water quantity available to each category of users is allocated uniformly to all its individual users.

Thus, two square matrices 3×3 X and TP are defined representing the sales of water rights taking place between the three categories of users and the prices per cubic meter of water paid as a fare for the water rights from the buyer to the seller respectively. In particular, the element x_{ij} of the matrix X symbolizes the water quantity sold from category of users i to category j while the element tp_{ij} of the matrix TP symbolizes the price per cubic meter of water paid by category of users i to category j as a fare for the water rights they purchase from them. At this point the following should be pointed out: in fact for each category of users there are two prices one corresponding to the price that they are willing to pay in order to purchase water rights from another category of users and another one corresponding to the price they are willing to accept as fare in order to sell water rights to another category of users. However, the element tp_{ij} is not identical to either of them but it is an intermediate price between the two, which results from the negotiation between the buyer and the seller. Therefore, in accordance with the above the net benefit NB_i for each category of users results from the following equation:

$$NB_i = B_i - p_i * q_i + \sum_{j=1}^3 tp_{ji} * x_{ij} - \sum_{j=1}^3 tp_{ij} * x_{ji} \quad (2)$$

where B_i the benefit the category of users i derives from water consumption, tp_{ji} the price per cubic meter of water paid by the category of users j to the category i in order to purchase a water quantity x_{ij} from them and similar tp_{ij} the price per cubic meter of water paid by the category of users i to the category j in order to purchase a water quantity x_{ji} from them.

Then, the net benefit function of each category is defined as well as the constraints of the proposed model.

Domestic use

The benefit of water consumption for the domestic users and in particular the benefit function for them is derived from an inverse demand function $p = f^{-1}(Q)$ for water (Rosegrant et al., 2000). According to Reynaud (2015) the demand for water in Greece depends on its price, consumer income and other external factors. If it is considered for the sake of simplicity that the demand for water is only a function of its price, then a water demand function for Greece may be as the following (Reynaud, 2015):

$$\ln Q = a \ln p + \ln c \quad (3)$$

where Q the water quantity demanded, a the price elasticity of water, p the price of water for domestic users and c a constant incorporating the other stable factors. The inverse demand function is derived from equation (3) as follows:

$$[3] \Rightarrow \ln Q = a \ln p + \ln c \Rightarrow \ln Q = \ln(p^a * c) \Rightarrow Q = p^a * c \Rightarrow p = \left(\frac{Q}{c}\right)^{1/a} \quad (4)$$

According to McKinney and Savitsky (2006) the benefit B obtained by an individual consumer from the consumption of a quantity of a good Q is equal to the area under the graph of the function $p = f^{-1}(Q)$ and is defined by the vertical axis and the vertical line corresponding to the quantity of good consumed, i.e. it is:

$$B = \int_0^Q p(Q) dQ \quad (5)$$

The equation (5) can be considered to reflect the benefit that an individual consumer derives from the consumption of a water quantity Q . In the context of the implementation of the concept of tradable water permits being studied the category of domestic users benefits not only from the initial water quantity q_1 granted to it but also from the water quantities it may purchase from the other categories of users, while at the same time it loses the benefit it would derive from the water quantities it might sell to the other categories of users. Consequently, generalising the case of the individual consumer the benefit B_1 for the domestic users, whose population amounts to R inhabitants, from water consumption results as follows:

$$B_1 = R * [\int_0^{q_1 + \sum_{j=1}^3 x_{j1}} p(Q) dQ - \int_0^{\sum_{j=1}^3 x_{1j}} p(Q) dQ] = R * \int_{\sum_{j=1}^3 x_{1j}}^{q_1 + \sum_{j=1}^3 x_{j1}} p(Q) dQ = R * \int_{\sum_{j=1}^3 x_{1j}}^{q_1 + \sum_{j=1}^3 x_{j1}} \left(\frac{Q}{c}\right)^{1/a} dQ =$$

$$R * \left[\frac{c}{1+1/a} * \left(\frac{Q}{c}\right)^{1/a+1} \right]_{\sum_{j=1}^3 x_{1j}}^{q_1 + \sum_{j=1}^3 x_{j1}} = R * \frac{c}{1+1/a} * \left[\left(\frac{q_1 + \sum_{j=1}^3 x_{j1}}{c}\right)^{1/a+1} - \left(\frac{\sum_{j=1}^3 x_{1j}}{c}\right)^{1/a+1} \right] \quad (6)$$

Finally, the net benefit function for the domestic users can be written through the equations (2) and (6) as follows:

$$NB_1 = R * \frac{c}{1+1/a} * \left[\left(\frac{q_1 + \sum_{j=1}^3 x_{j1}}{c}\right)^{1/a+1} - \left(\frac{\sum_{j=1}^3 x_{1j}}{c}\right)^{1/a+1} \right] - p_1 * q_1 + \sum_{j=1}^3 tp_{j1} * x_{1j} - \sum_{j=1}^3 tp_{1j} * x_{j1} \quad (7)$$

Agricultural use

The net benefit for the agricultural users, i.e. the farmers, coincides with the economic benefit they derive from their crops taking into account of course the additional revenues or costs arising from the trading of water rights. According to this assumption and what has preceded the farmers' net benefit results from the following equation:

$$NB_2 = p_a * A * f(Q) - C_{agr} - p_2 * q_2 + \sum_{j=1}^3 tp_{j2} * x_{2j} - \sum_{j=1}^3 tp_{2j} * x_{j2} \quad (8)$$

where p_a the selling price of the agricultural products, A the total cultivating area, $f(Q)$ a production function that estimates agricultural production on the basis of water consumption Q and C_{agr} the other input costs associated with agricultural production and are not related to water.

A typical function that estimates the agricultural production per hectare (ha) of cultivating area on the basis of water quantity consumed Q_{agr} in m^3/ha is the following (Varzi, 2016):

$$f(Q_{agr}) = a_0 + b_0 * Q_{agr} + c_0 * Q_{agr}^2 \quad (9)$$

where a_0, b_0, c_0 coefficients depending on the type of crop.

The water quantity consumed by farmers Q_{agr} is equal to the initial water rights received plus the water quantity purchased by the other categories of users minus the corresponding quantity sold to the other categories of users and divides by the total cultivating area A in ha , i.e. it is:

$$Q_{agr} = (q_2 + \sum_{j=1}^3 x_{j2} - \sum_{j=1}^3 x_{2j}) / A \quad (10)$$

Hence, the net benefit function for farmers can be written as follows:

$$(8) \xrightarrow{(9),(10)} NB_2 = p_a * A * \left[a_0 + b_0 * (q_2 + \sum_{j=1}^3 x_{j2} - \sum_{j=1}^3 x_{2j}) / A + c_0 * \left[\frac{(q_2 + \sum_{j=1}^3 x_{j2} - \sum_{j=1}^3 x_{2j})}{A} \right]^2 \right] - C_{agr} - p_2 * q_2 + \sum_{j=1}^3 tp_{j2} * x_{2j} - \sum_{j=1}^3 tp_{2j} * x_{j2} \quad (11)$$

Industrial use

The net benefit for the industrial users arises in a similar way to that applied to agricultural users, since this also coincides with the benefit they derive from the sales of the products they manufacture taking, of course, into account the additional revenues or costs arising from the trading of water rights. According to this the net benefit NB_3 for the industrial users will be:

$$NB_3 = p_{ind} * P(Q) - C_{ind} - p_3 * q_3 + \sum_{j=1}^3 tp_{j3} * x_{3j} - \sum_{j=1}^3 tp_{3j} * x_{j3} \quad (12)$$

where p_{ind} the selling price of industrial products, $P(Q)$ a production function that estimates the industrial production on the basis of the water quantity used and C_{ind} the other input costs associated with industrial production and are not related to water.

The industrial production $P(Q)$ is connected with the water quantity consumed by the industrial users Q_{ind} through a conversion coefficient a_{ind} , which is given by the following equation:

$$a_{ind} = \frac{Q_{ind}}{P(Q)} \quad (13)$$

The water quantity consumed by the industrial users Q_{ind} is equal to the initial water rights received plus the water quantity purchased by the other categories of users minus the corresponding quantity sold to the other categories of users, i.e. it is:

$$Q_{ind} = q_3 + \sum_{j=1}^3 x_{j3} - \sum_{j=1}^3 x_{3j} \quad (14)$$

Therefore, the net benefit function for the industrial users can be written as follows:

$$(14) \xrightarrow{(12),(13)} NB_3 = p_{ind} * \frac{(q_3 + \sum_{j=1}^3 x_{j3} - \sum_{j=1}^3 x_{3j})}{a_{ind}} - C_{ind} - p_3 * q_3 + \sum_{j=1}^3 tp_{j3} * x_{3j} - \sum_{j=1}^3 tp_{3j} * x_{j3} \quad (15)$$

Constraints

After defining the net benefit functions for the users, the constraints of the problem have to be formed. First of all, for environmental reasons a constraint concerning the water balance has to be placed the main expression of which is the equation (16). The equation (16) is applied for specific time step Δt , which is one year for this paper's model and means that the change in the water volume stored in the aquifer being examined is equal to the difference between the inflow I and the outflow Q (Mimikou and Fotopoulos, 2004). The change ΔS may be either positive or negative and so the water balanced is described as redundant or deficient respectively. The inflow I into an aquifer is equal to the percolation, i.e. the percentage of precipitation (rainfall and snowfall) that penetrates the ground surface and is filtered vertically into the aquifer taking into account the restocking of the aquifer by resupplying part of the water consumed for the various uses (Latinopoulos, 2003). The outflow Q is equal to the initial water rights granted to the users, i.e. it is $Q = \sum_{i=1}^3 q_i$. Hence, in order for the water balance to be redundant or marginally redundant, the expression (17) has to be in effect.

Furthermore, in order to ensure a minimum water quantity for the domestic users to meet their basic needs, it is decided that the water quantity available for consumption to them (the initial rights granted to them plus the purchases of water rights minus the sales of water rights) must correspond to at least 10% of the total water quantity available, i.e. the expression (18) has to be in effect.

$$\Delta S / \Delta t = I - O \quad (16), \quad \frac{\Delta S}{\Delta t} = I - \sum_{i=1}^3 q_i \geq 0 \quad (17), \quad q_1 + \sum_{j=1}^3 x_{j1} - \sum_{j=1}^3 x_{1j} \geq 0.1 * \sum_{i=1}^3 q_i \quad (18)$$

Additionally, each category of users i can not sell more than the water quantity initially allocated to them plus the water quantity they may purchase from the other categories of users, i.e. the expression (19) has to be true. Moreover, it is obvious that one category of users is not able to sell water rights to itself, so the expression (20) has to apply.

$$\sum_{j=1}^3 x_{ij} \leq q_i + \sum_{j=1}^3 x_{ji}, \quad i = 1 \dots 3 \quad (19), \quad x_{11} = 0, \quad x_{22} = 0, \quad x_{33} = 0 \quad \& \quad tp_{11} = 0, \quad tp_{22} = 0, \quad tp_{33} = 0 \quad (20)$$

Water rights transactions between the three categories of users are not bidirectional and that means that if one category of users sells water rights to another, then the second can not sell water rights to the former, so the expression (21) has to be true. It is also considered appropriate to introduce constraints regarding the minimum price per cubic meter of water paid as a fare for the acquisition of water rights (excluding the elements tp_{11} , tp_{22} και tp_{33}), which has to be at least equal to the allocation price of the initial water rights for each category of users, i.e. the expression (22) has to apply. Finally, it is desired for each category of users not to be harmed by the transactions of water rights, i.e. the expression (23) has to be in effect.

$$x_{12} * x_{21} = 0, \quad x_{13} * x_{31} = 0, \quad x_{23} * x_{32} = 0 \quad (21), \quad tp_{ij} \geq p_i, \quad i, j = 1 \dots 3 \quad (22), \quad NB_i \geq 0, \quad i = 1 \dots 3 \quad (23)$$

Comprehensive enunciation of the proposed model

Taking into account all of the above, the final form of the proposed model occurs which is as follows:

$$\begin{aligned} \max NB_{tot} = \sum_{i=1}^3 NB_i = R * \frac{c}{1+1/a} * \left[\left(\frac{q_1 + \sum_{j=1}^3 x_{j1}}{c} \right)^{1/a+1} - \left(\frac{\sum_{j=1}^3 x_{1j}}{c} \right)^{1/a+1} \right] - p_1 * q_1 + \sum_{j=1}^3 tp_{j1} * x_{1j} - \\ \sum_{j=1}^3 tp_{1j} * x_{j1} + \{ p_a * A * \left[a_0 + b_0 * (q_2 + \sum_{j=1}^3 x_{j2} - \sum_{j=1}^3 x_{2j}) / A + c_0 * \left[\frac{(q_2 + \sum_{j=1}^3 x_{j2} - \sum_{j=1}^3 x_{2j})}{A} \right]^2 \right] \\ - C_{agr} - p_2 * q_2 + \sum_{j=1}^3 tp_{j2} * x_{2j} - \sum_{j=1}^3 tp_{2j} * x_{j2} \} + \left[p_{ind} * \frac{(q_3 + \sum_{j=1}^3 x_{j3} - \sum_{j=1}^3 x_{3j})}{a_{ind}} - C_{ind} - p_3 * q_3 + \right. \\ \left. \sum_{j=1}^3 tp_{j3} * x_{3j} - \sum_{j=1}^3 tp_{3j} * x_{j3} \right] \end{aligned}$$

s.t.

$$\begin{aligned} \Delta S / \Delta t = I - O \geq 0, & \quad x_{12} * x_{21} = 0, \quad x_{13} * x_{31} = 0, \quad x_{23} * x_{32} = 0, \\ q_1 + \sum_{j=1}^3 x_{j1} - \sum_{j=1}^3 x_{1j} \geq 0.1 * \sum_{i=1}^3 q_i, & \quad tp_{ij} \geq p_i, \quad i, j = 1 \dots 3, \\ \sum_{j=1}^3 x_{ij} \leq q_i + \sum_{j=1}^3 x_{ji}, \quad i = 1 \dots 3, & \quad NB_i \geq 0, \quad i = 1 \dots 3 \text{ and} \\ x_{11} = 0, \quad x_{22} = 0, \quad x_{33} = 0, \quad tp_{11} = 0, \quad tp_{22} = 0, & \quad q_i \geq 0, \quad i = 1 \dots 3, \quad x_{12} \geq 0, \quad x_{21} \geq 0, \quad x_{13} \geq 0, \quad x_{31} \geq 0, \\ 0, \quad tp_{33} = 0, & \quad 0, \quad x_{23} \geq 0, \quad x_{32} \geq 0 \end{aligned}$$

The resolution of the proposed model will lead to the determination of the water quantities which have to be initially allocated to the users, the water quantities which they have to trade with each other and the corresponding prices that have to be paid in order to maximise the total net benefit of the society.

CONCLUSIONS

In conclusion, the optimization model presented is an integrated proposal on the allocation of water to competitive users based on tradable water permits. In general, it is a complex model with many parameters that need to be estimated and this is the most important obstacle to its practical implementation. However, the recent literature may be the solution to overcome this obstacle since it can provide numerical values for the parameters required. Hence, due to recent literature which provided the essential numerical data the implementation of the model is in progress and is about to be fully presented in a subsequent paper. From the first results that emerge, there seems to be a tendency for the agricultural production to be abandoned and for the water that it would consume to be consumed by industry, which therefore produces very large quantities of products. This tendency can not definitely be realistic because on the one hand each industrial plant has specific production capabilities that depend on factors such as its machinery, the workforce it employs and the ability of its suppliers to provide it with raw materials and on the other hand the market to which an industrial plant is focused on may not be able to absorb high levels of production. Given that the model presented is time-static, it is worth investigating how it works in the long term, i.e. taking into account the parameter of time and additional parameters such as those described in the previous sentence.

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A Modified BLOCPLAN Algorithm for Unequal Area Facility Layout Planning

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Abstract

BLOCPLAN is a simple facility layout algorithm that arranges rectangular departments into horizontal bands. To design a new layout, BLOCPLAN first generates an initial plan by randomly assigning departments to bands. Using the initial layout as a baseline, the algorithm then performs exchanges between departments to create alternative solutions. This exchange of departments continues until an improved plan is obtained. One disadvantage of the BLOCPLAN algorithm is that the quality of the final solution is highly dependent on the randomly generated initial layout. To overcome this problem, the process will often be repeated multiple times with different initial layouts. However, the effectiveness of this approach diminishes as the problem size gets larger. In our study, we propose an alternative exchange mechanism that prevents premature convergence, generating a better final solution irrespective of the starting layout. With the standard BLOCPLAN algorithm, only a two-way exchange of departments is allowed. Our proposed approach retains the two-way exchange protocol, but also permits one-way removal and reinsertion of a single department. This is achieved by defining virtual departments with zero width, positioned between “real” departments. By allowing exchange between real and virtual departments, we mimic the removal-insertion process of a department. The removal-insertion mechanism, in conjunction with standard two-way exchanges, expands the search space for alternative solutions, offering better convergence and higher quality final solutions relative to those obtainable through only standard two-way exchange.

KEYWORDS

blocplan, two-way exchange, local optimum, multi-start search

INTRODUCTION

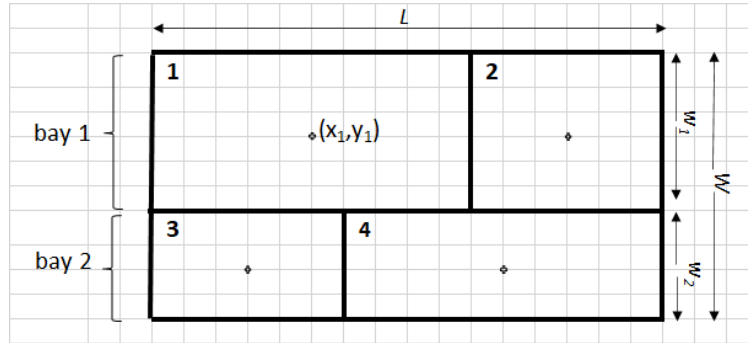
The facility layout problem (FLP) refers to the spatial placement of facilities, departments, and machines in a specified physical enclosure. The placement of production means is a complex issue affecting many areas related to production, such as material handling, product mix selection, inventory management, etc. From a technical perspective, the layout design problem refers to the partitioning of a planar area with a length and width of ($L \times W$) into N departments. There is an interdepartmental material flow requirement, and the cost associated with the flow is often called the material handling cost. The objective is to minimize the total material handling cost (z) of the layout, as expressed in Equation 1.

$$z = \sum_{i=1}^N \sum_{j=1, i \neq j}^N c_{ij} f_{ij} d_{ij} \quad (1)$$

where f_{ij} is the amount of material flow between department i and j ; d_{ij} is the distance in a specified metric; c_{ij} is the unit carrying cost, which is the cost of carrying one unit of material for one unit distance between i and j . Two main constraints of the problem are the area requirements of each department and the dimensional integrity of the layout. The output of FLP is a block layout plan that defines the relative location and shape of each department.

FLP can be formulated in different ways. One commonly used method is the flexible bay structure (FBS), which partitions a facility into columns or bays. In FBS, each department is confined to a single bay (Fig. 1). Bays may vary in width and number of departments they contain.

Figure 1: A Four-department Sample FBS. Departments 1 and 2 have a width of w_1 . Departments 3 and 4 have a width of w_2 .



FBS formulation reduces the complexity of the general FLP as the line between bays becomes an aisle, and the model can be directly transformed into the actual facility design (Konak et al., 2006). FBS was first proposed by Tong (1991) and has since been used by numerous researchers (Tate & Smith, 1995; Arapoğlu et al., 2001; Enea et al., 2005). Algorithms similar to FBS are also used in layout design software such as SPIRAL (Goetschalckx, 1992) and BLOCPLAN (Donaghey & Pire, 1990).

BLOCPLAN utilizes an FBS structure in which departments are organized within several bands. The number of bands is *a priori* selected. Layout algorithms are classified into two groups, namely construction and improvement algorithms (Huragu, 2008; Tompkins et al., 2010). Construction algorithms create a new layout from scratch, while improvement algorithms start from an existing plan. One drawback of the BLOCPLAN algorithm is that the quality of the final solution is highly dependent on the randomly generated initial layout. BLOCPLAN uses two-way exchanges to modify an existing layout. Once the initial assignment of departments is complete, a two-way exchange of departments is the only mechanism to generate alternative solutions. This is a restrictive mechanism and prevents the algorithm from creating alternatives that are radically different from the initial solution. Less variety in layout generation may lead to premature convergence to lower quality solutions. We propose a methodology that overcomes the restrictive alternative generation mechanism of the original BLOCPLAN algorithm. Our approach leads to faster convergence to higher quality solutions.

COMPUTATIONAL RESULTS

To more clearly demonstrate the differences between the standard BLOCPLAN algorithm and our modified version, we apply both methods to a simple example and then compare the results. We also discuss the relative performance of the two approaches when applied to a large test case consisting of 10 departments.

BLOCPLAN Algorithm

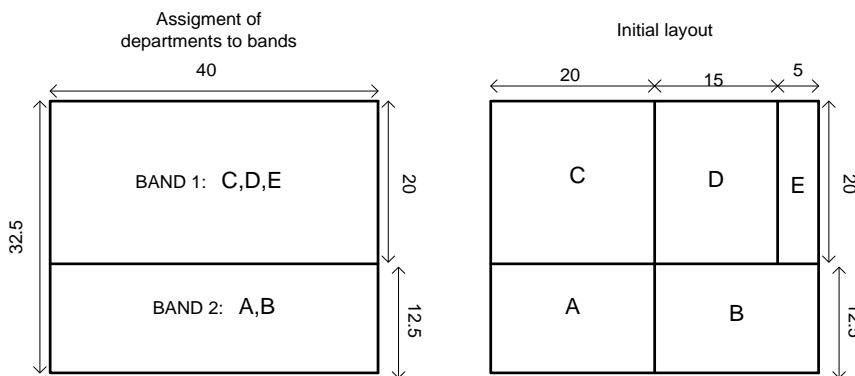
The BLOCPLAN algorithm consists of two primary steps. If there is no starting layout at hand, then the construction of the starting layout constitutes the first step. The second step is an iterative process whereby alternative layouts are constructed and evaluated for improvement. An illustrative example of a five-department layout problem is given in Table 1, which presents flow quantity and department areas. The plant has a length of 40 units and a width of 32.5 units. The maximum aspect ratio (length/width ratio) is set to 10, and departments are assigned to one of two bands. The objective is to minimize the total flow cost among departments, defined as the product of flow and distance between any two departments in Equation 1.

Figure 1 shows the steps involved in constructing an initial layout. Once we randomly assign departments to bands, we can calculate the width of each band by dividing the sum of the department areas by the facility length. Within each band, departments are placed in the order in which they are assigned to the corresponding band.

Table 1: Five-Department Layout Problem

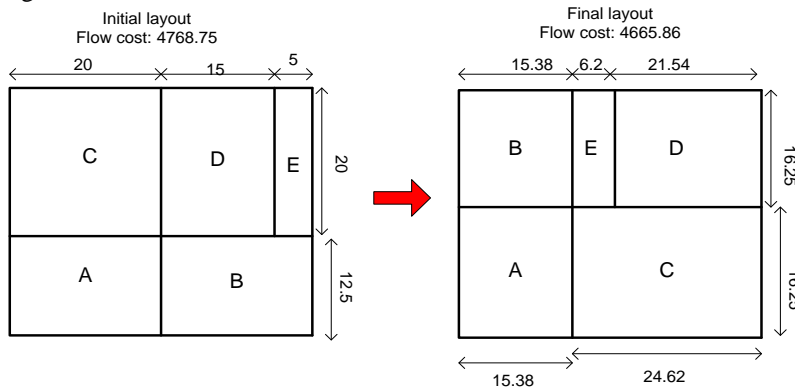
Department	Area	Flow Between Departments				
		A	B	C	D	E
A	250	0	45	15	25	10
B	250	0	0	0	20	35
C	400	20	0	0	0	5
D	300	0	20	0	0	35
E	100	0	0	0	0	0

Figure 1: Construction of the Initial Layout



After the construction of the initial layout, the BLOCPLAN algorithm generates alternative layouts by swapping departments. For any two-way swap, there are $\binom{5}{2} = 10$ combinations. During the iterative search process, the BLOCPLAN algorithm creates an *a priori* determined number of alternative layouts at each generation. The best among the alternatives is then selected as a basis for the next generation. The process continues until no further improvement is achieved. For the test case given in Table 1, the final solution is shown in Figure 2.

Figure 2: Initial and Final Solution



Modified BLOCPLAN Algorithm

As previously stated, the performance of the BLOCPLAN algorithm is highly dependent on the initial solution. The algorithm’s sole mechanism for generating a new layout is to exchange two departments, which limits the variety of layouts and creates a limited number of alternatives. In the BLOCPLAN algorithm, the number of departments assigned to each band cannot be changed during the search process. This can be very restrictive, especially if there is a tight aspect ratio constraint to avoid elongated departments. To overcome this problem, we are proposing a less restrictive approach in terms of generating alternative layouts. The upgrading mechanism will remove any department from the layout, and then to reinsert it in a different position in the layout.

Figure 3 depicts the application of the modified BLOCPLAN algorithm on the same test case. In addition to the original five departments, seven new virtual departments are added to the layout. These departments have an area of zero, but they can be exchanged with the “real” departments. On the left-hand side of Figure 3, the exchange between the “real”

department “E” and the virtual department “v5” is illustrated. This exchange renders the layout displayed on the right-hand side of Figure 3. Although, algorithmically, this is a simple exchange of two departments, it creates an alternative that could not otherwise be generated.

Figure 3: Modified Approach with Virtual Departments

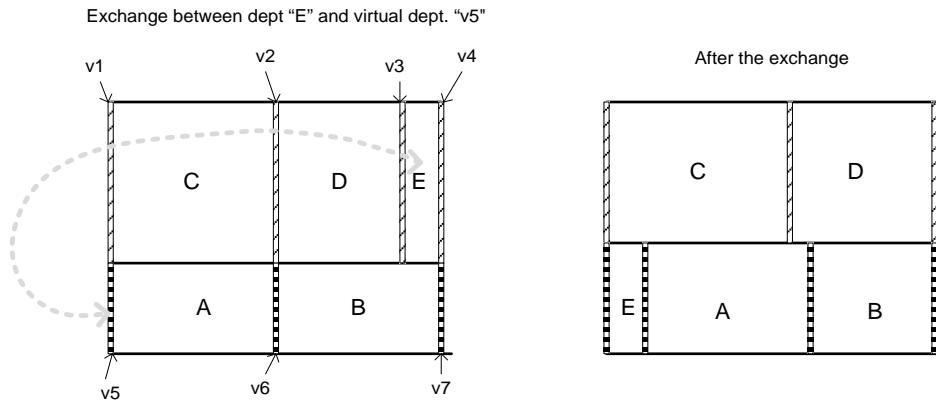
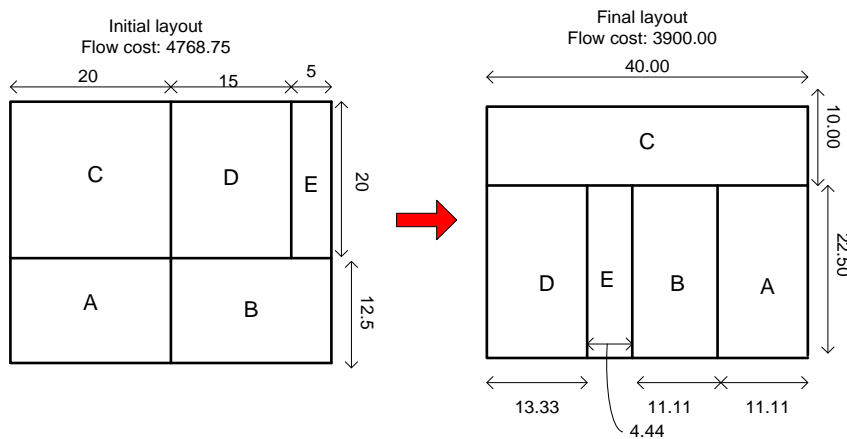


Figure 4 depicts the initial layout, along with the final solution generated by the modified algorithm. The randomly generated initial layout has a flow cost of 4768.75 units. When the modified algorithm was run on the same problem, it found a better solution with a total flow cost of 3900.00 units. In terms of run time, the average standard BLOCPLAN algorithm found the final solution in 7.7 seconds. For the modified BLOCPLAN, the average run time was 14.4 4.5 seconds.

In the randomly generated initial layout, the upper and lower bands comprise two and three departments, respectively. BLOCPLAN has no mechanism to change the number of departments assigned to each band (Figure 2). With the modified version, this hurdle is removed. The solution generated by the modified algorithm moved two of the three departments from the upper band to the lower band, resulting in a significant improvement in total flow cost (Figure 4).

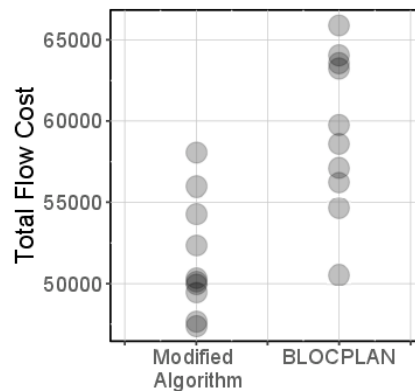
Figure 4: Modified Approach with Virtual Departments



A Large Test Case

The two approaches were tested on a large test case consisting of 10 departments. The algorithms were run in pairs with the same random seed, with each run replicated 10 times. Figure 5 shows the distribution of the final solutions generated by each method. For the modified algorithm, the mean and standard deviation are 51,561 and 3,556 units, respectively. For the standard algorithm, these are 59,356 and 4,861 units. The run times for the standard and modified algorithms are 11.68 and 19.28 seconds, respectively.

Figure 5: Modified Approach with Virtual Departments



CONCLUSIONS

As indicated in Figure 5, the proposed algorithm offers superior performance compared to the standard BLOCPLAN algorithm. In terms of both average solution value and optimal solution value (i.e., lowest total cost), the modified algorithm offers better results. To obtain more conclusive findings, the two algorithms need to be tested on more cases; in addition, computation times should be taken in more runs. While the modified approach appears to produce better results, it comes at a higher computational cost.

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Session 2: Multiple Criteria Decision Analysis

chair: Dimitrios Drosos

An Examination of the Relationships between Customers' Satisfaction and Business Performance: The Case of Greek Mobile Industry

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Abstract

Over the last two decades mobile communications industry is considered as one of most important and rapidly growing sectors of the economy around the world. In Greece the mobile communications sector is considered as one of the most importantly developed sectors of the economy. At the end of 2018, the Industry turnover reached at 4.8 billion euros, while its contribution to Greece's Gross Domestic Product (GDP) was 2.6%, showing a decreasing trend comparing to 2017. Customers' satisfaction is one of the key components for the industrial development. Many researchers argue that there is a strong, positive relationship between customer satisfaction and business performance. The aim of this study is to examine the relationship between customers' satisfaction from the three larger mobile companies participated in Greece (Cosmote, Vodafone and Wind) and the business performance of these companies. The reported customers' satisfaction was analyzed with the Multicriteria Satisfaction Analysis (MUSA) method, which is considered as an aggregation-disaggregation approach developed on the qualitative analysis regression. The implementation of this survey was structured through the development of a web site questionnaire, addressing customers' satisfaction of the aforementioned three mobile telecommunications companies. Comparable analysis of the relationship between business performance and customers' satisfaction, it was deployed by using regression models and correlation coefficients. The research findings unveiled that customers' satisfaction and business performance are positively related.

KEYWORDS:

Customer Satisfaction, Business Performance, Mobile Industry, Multicriteria Analysis, MUSA Methodology

INTRODUCTION

During the last decade vivid interest in measuring customer satisfaction levels has been noticed by numerous studies worldwide. The research objective of measuring customer satisfaction levels has been empowered by the need for evaluation and improvement on the quality of products' and services' offered. The perception of customer satisfaction has been investigated at the international bibliography as a reliable index for the evaluation of businesses' operation. Marketing academics have recently emphasized on how customer satisfaction affect the bottom-line business performance of firms. The linkages between customer satisfaction and business performance have drawn an ongoing literature attention worldwide. Many researches have extensively explored the linkages developed between customer attitudes and business performance (Anderson and Sullivan, 1993; Morgan and Rego, 2006; Reichheld and Teal, 1996; Otto et al., 2020; Golovkova et al., 2019; Cuevas-Vargas et al., 2019). The general consensus is that higher customer satisfaction leads to higher levels of repurchase intention, customer advocacy, and customer retention. Over the last two decades one of the rapidly growing and competitive industries in the service sector is the mobile communications industry. In our digital era mobile communications industry is playing a decisive role in every human aspect. Besides, in the increasingly competitive organisations operated at mobile communications are certainly focusing on their customer satisfaction (Drosos et al., 2015). Mobile communications industry is one of the most important business sectors of the Greek economy since it contributes to the national income growth, the increase of government revenue and the creation of new jobs (Drosos et al., 2011; Goyal and Kar, 2020; Abor et al., 2018). The Greek mobile telephony market is comprised of three firms, namely, Cosmote which owns the largest market share over time, Vodafone, and Wind (Rizomyliotis et al., 2018). The scope of this study is to analyse the relationship developed between customer satisfaction and business performance using data from the mobile communications industry in Greece.

THE RELATIONSHIP BETWEEN CUSTOMER SATISFACTION AND BUSINESS PERFORMANCE

Quality and customer satisfaction are key drivers of business performance. Business performance is an important component in determining the successful organization and operation of a business. Business results can be measured in both financial and non-financial terms (Bontis, 1998; Bontis et al., 2000). Business performance can be determined both by objective measurements, such as return on investment, profits and sales, turnover, productivity, market share, and by subjective measures such as the organization of the business, the existence of processes, its reputation. company. Many empirical studies confirm a positive as well as a negative relationship between customer satisfaction and a company's performance. Researches have shown in recent years that continuous improvement in quality and customer satisfaction are key components that are directly or indirectly related to the performance of companies. Many researchers and scientists argue that customer satisfaction is positively related to the desired effectiveness of a business. Research has shown the measurable effect of customer satisfaction on their intention to: firstly, repurchase a product or service offered by companies (Bolton and Drew, 1991a; Mittal et al., 1999), secondly, customer retention (Anderson and Sullivan, 1993; Bolton, 1998; Ittner and Larcker, 1998; Mittal and Kamakura, 2001) as well as, thirdly, financial performance of the company (Anderson and Mittal, 2000; Fornell et al., 1996, Rust and Zahorik, 1993; Jones and Sasser, 1995; Chaudhuri and Holbrook, 2001; Fournier, 1998; Oliver, 1999). On the other hand, there are many researchers who denote a negative linkage between customer satisfaction and business effectiveness, such as the Griliches (1971) and Lancaster (1979) who argued that there is a negative correlation between customer satisfaction and business efficiency. Customer satisfaction is perceived as a function of the properties of products' or services' offered. However, the upgrading of level of services entails the improvement of raw materials and the intensification of human resources, all resulting in increased costs of production and purchasing.

RESEARCH METHODOLOGY

For the purpose of this study an electronic questionnaire was used for data collection. This is an empirical study that ran for the five consequent years between 2013 and 2017. A total of 6,968 questionnaires concerning customer satisfaction were collected. The satisfaction criteria in this survey were based on bibliographical research. Many researchers developed questionnaires in order to measure the customer satisfaction in several different sectors (Grigoroudis and Siskos, 2010; Manolitzas et al., 2010; 2010; Drosos and Tsotsolas, 2014; Chalikias et al., 2016; Skordoulis et al., 2017; Drosos et al., 2018; Zerva et al., 2018; Drosos et al., 2019; Drosos et al., 2020). The satisfaction criteria consists of the following main characteristics: 1) Products-services: it refers to the satisfaction from products and services, 2) GSM network: it is the network of the mobile communications firm, 3) Stores: it refers to the location of stores and the network of branches that have been developed by the companies, 4) Human resources: it refers to the satisfaction from branches' or contacted centres' staff, 5) Customer service: it refers to consumer satisfaction from client gains when communicating with the staff of the mobile operator in the branch or through the contact center, 6) Prices: it focuses on the costs of services, 7) Webpage: it indicates the satisfaction from the website of each company. Furthermore, secondary data concerning Indices by the mobile communications firms were collected in order to examine the relationship between firms and customer satisfaction. These Indices were structured based on the following effectiveness indexes regarding the "Total Number of": Active Subscribers; Prepaid Cards; Contracts; Subscribers. The correlation of customer satisfaction from business performance Indices was carried out using the statistical methods of the Spearman's rank correlation coefficient ρ and Linear Regression. The MUSA method was used in order to measure customer satisfaction. The method is an ordinal-regression-based approach used for the assessment of a set of collective satisfaction functions in such a way that the global satisfaction criterion becomes as consistent as possible with customers' judgments. In particular, the method infers an additive collective value function Y^* and a set of partial satisfaction (value) functions X_i^* , given customers' global satisfaction Y and partial satisfaction X_i according to the i -th criterion (ordinal scaling). The main objective of the method is to achieve the maximum consistency between the value function Y^* and the customers' judgments Y . Based on the modeling of preference disaggregation approach, the ordinal regression equation is:

$$\begin{cases} Y^* = \sum_{i=1}^n b_i X_i^* \\ \sum_{i=1}^n b_i = 1 \end{cases} \quad (1)$$

Where \tilde{Y}^* represents the estimation of the global value function, n represents the number of criteria, b_i is a positive weight of the i -th criterion, σ_+ and σ_- are the overestimation and the underestimation errors, respectively, and the value functions Y^* and X_i are normalized in the interval $[0,100]$. The global and partial satisfaction Y^* and X_i^* are

monotonic functions normalized in the interval [0,100]. Thus, in order to reduce the size of the mathematical program, removing the monotonicity constraints for Y^* and X_i^* , the following transformation equations are used:

$$\begin{cases} z_m = y^{*m+1} - y^{*m} & \text{for } m = 1, 2, \dots, a - 1 \\ w_{ik} = b_i(x_i^{*k+1} - x_i^{*k}) & \text{for } k = 1, 2, \dots, a_i - 1 \text{ } \forall i = 1, 2, \dots, n \end{cases} \quad (2)$$

where y^{*m} is the value of the y_m satisfaction level, x_i^{*k} is the value of the x_{ik} satisfaction level, and α and α_i are the number of global and partial satisfaction levels. According to the aforementioned definitions and the assumptions, the basic estimation model can be written in a linear program formulation, as follows:

$$\left\{ \begin{array}{l} [\min]F = \sum_{j=1}^M \sigma_j^+ + \sigma_j^- \\ \text{under the constraints:} \\ \sum_{i=1}^n \sum_{k=1}^{t_{ji}-1} w_{ik} - \sum_{m=1}^{t_j-1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \forall j = 1, 2, \dots, M \\ \sum_{m=1}^{a-1} z_m = 100 \\ \sum_{i=1}^n \sum_{k=1}^{a_j-1} w_{ik} = 100 \\ z_m, w_{ik}, \sigma_j^+, \sigma_j^- \geq 0 \quad \forall m, i, k, j \end{array} \right. \quad (3)$$

where M is the number of customers, n is the number of criteria, and x_i^{*j} , y^{*j} are the j -th level on which variables X_i and Y are estimated.

RESULTS AND COMMENTS

Based on Table 1 it is shown a positive correlation between global satisfaction and business performance indicators without any of it to be statistically significant. The highest statistical correlation occurs between the total satisfaction and the index total number of subscribers ($p = 0.436$).

Table 1: Correlation Business Performance Indexes and Global Satisfaction (Spearman's rho)

	Total Number of Active Subscribers	Total Number of Prepaid Cards	Total Number of Contracts	Total Number of Subscribers
Customer Satisfaction	0,282	0,361	0,107	0,436

** . Correlation is Significant at 0,01 Level (2 Tailed) / * . Correlation is Significant at 0,01 Level (2 Tailed).

Considering the results of the correlation between customer satisfaction and business results indicators, it seems that customer satisfaction and business results of mobile companies are positively related. According to the data in the following Table 2 there is no significant statistical correlation between satisfaction criteria and business performance indicators. As can be seen at Table 2 the highest statistically positive correlation is noted at the Total Number of Contracts index based on GSM Network ($p = 0.500$). Besides, in the Total Number of Active Subscribers index based on the GSM Network it appears to be a statistically positive correlation ($p = 0.421$).

Table 2: Correlation Profitability Indices and Satisfaction Criteria (Spearman's rho)

Satisfaction Criteria \ Indices	Total Number of Active Subscribers	Total Number of Prepaid Cards	Total Number of Contracts	Total Number of Subscribers
Products Services	0,014	-0,054	-0,029	0,061
GSM Network	0,421	0,321	0,500	0,279
Stores	-0,011	-0,071	-0,018	-0,061
Human Resources	0,325	0,339	0,200	0,407
Customer Service	0,364	0,300	0,157	0,346
Pricing Policy	-0,036	-0,018	-0,125	0,029
Web Page	0,196	0,061	0,164	-0,046

** . Correlation is Significant at 0,01 Level (2 Tailed) / * . Correlation is Significant at 0,01 Level (2 Tailed).

CONCLUSION

Many researchers argued that customer satisfaction can provide a strategic foundation for generating a competitive advantage for many organisations (Nilsson et al., 2001). The importance of customer satisfaction for business performance has been the core research objectives for many studies. Particularly, there are studies stating a positive correlation while other studies denoted a negative one. The results of our study indicated a positive and statistically significant correlation between customer satisfaction and the Indices concerning the Total Number of Active Subscribers, the Total Number of Prepaid Cards, the Total Number of Contracts and the Total Number of Subscribers. These results further unveiled that despite the majority of firms recognise customer satisfaction as a tool for their strategy development, they do not utilize relevant indicators in measuring their performance. Therefore, it is of utmost importance factor for contemporary firms to utilize customer satisfaction as a valuable managerial indicator to obtain quantitative information for their performance. Based on the conclusions drawn and the results yielded, several future research paths are proposed. First, more analytical researches can be conducted to include the aforementioned factors' related to customer satisfaction. Second, at the same time, future researches should also focus on satisfaction benchmarking analysis, considering the rapidly evolving socioeconomic conditions. Third, an important methodological advancement should be the installation, and annually running, permanent satisfaction barometer.

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Customers' satisfaction and Market Share: An Approach of the Greek Mobile Sector

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Abstract

Over the past decades the telecommunications industry is proven one of the most dynamic and competitive industrial sector around the world. Mobile communications have become an integral part of the industrial sector. In Greece the telecommunications industry is considered as one of the most importantly developed sectors of the economy, with high added-value services. The contribution of the industry's turnover to Greek Gross Domestic Product (GDP) was 2.6% in 2018. Market share and customer satisfaction are commonly used as key performance indicators to evaluate marketing performance. Market share and customer satisfaction are also used as key performance indicators in alignment with the overall financial management of an enterprise. This paper aims to shed light on the relationship between market share and customer satisfaction in the Greek mobile sector. Data were collected through questionnaires, which were structured in order to better understand customers' views on the service offered as well as the satisfaction levels on particular aspects of the service offered. Customers' satisfaction was measured using the MUSA method, a multi-criteria analysis based on the principles of qualitative regression. The relationship between customers' satisfaction and market share results has been analysed using correlation coefficients and regression models. The research findings unveiled a positive correlation between customers' satisfaction and market share.

KEYWORDS:

Customer Satisfaction, Market Share, Mobile Industry, Multicriteria Analysis, MUSA Methodology

INTRODUCTION

Within the last two decades the environment of business - organizations relationship is changing rapidly. The companies are adaptable to a globalized economic evolution, where their ultimate goal is customer satisfaction and consequently their consolidation of the "Global Village" while maintaining their competitive advantages that established them in the market. However, a necessary precondition to achieve a competitive advantage is both the provision of quality products - services and a better understanding of the external and the internal environment. The ultimate goal is balancing out the risks aroused as well as the most proactive or post-treatment measures taken (Porter, 1980; Porter, 1985). In our digital era, mobile communications industry has a significant role in every human activity. Besides, in the increasingly competitive mobile communication organisations are certainly focusing on their customer satisfaction (Goyal and Kar A, 2020; Yeboah-Asiamah et al., 2018; Abor et al., 2018; Drosos et al., 2015). Mobile communication is one of the most important technological sectors of the Greek economy since it contributes to the national income growth, the increase of government revenue and the creation of new jobs (Rizomyliotis et al., 2018; Drosos et al., 2011). Many studies have investigated the effect of customer satisfaction from market share in both service and products industries. Organisations confirmed that customer satisfaction can potentially lead to higher market share. Based on the above it is concluded that satisfied customers are developing a positive attitude towards the company and its offers result in customers' intention to repurchase its products or services. The linkage between market share and customer satisfaction stems from the fact that both concepts are related to quality. The aim of this paper is to analyse the relationship between customer satisfaction and market share using data from the mobile communications industry in Greece.

THE RELATIONSHIP BETWEEN CUSTOMER SATISFACTION AND MARKET SHARE

For the last two decades customer satisfaction has been the basis for companies, which aim to play a leading role in the modern financial situation worldwide. The purpose of a business is to initially satisfy customers with its products or

services, thus ensuring not the merely satisfied but the delighted customer (Boshoff and Gray, 2004). Customer satisfaction has been identified by managers as a strategic tool that essentially affects the process of decision making (Grigoroudis and Siskos, 2010). The philosophy of customer satisfaction, especially in alignment with international standards, it is not something new. A survey completed in 1988 in the US with the participation of 700 top executives of large companies, showed that for 64% of these executives, customer satisfaction was the first priority, while the other 36% stated that customer satisfaction is one of their top priorities (Shoultz, 1989). Market share and customer satisfaction have long been used as key performance indicators, not only in relation to marketing, but also in relation to the overall financial management of businesses. Over the years there has been developed a widespread behaviour of a positive or a negative linkage between customer satisfaction and market shares of businesses. Many researchers claimed that the level of customer satisfaction is positively related to the market share of a company at the market in which it operates (Buzzell and Gale, 1987, Jacobson and Aaker, 1987, Gale, 1992, Kordupleski et al., 1993; Oliver 1996; Phillips et al., 1983; Gounaris et al., 2002; Drosos et al., 2011; Rego et al., 2013). Based on the above it can signified that satisfied customers can develop a positive attitude towards the company in terms of customer intention to repurchase company's products or services. Likewise, it seems that customer satisfaction and market share are two interlinked concepts. At the same time, there are researchers who argued about the view of the negative correlation between customer satisfaction and market shares (Fornell, 1992; Kordupleski et al., 1993; Griffin and Hauser, 1993; Gounaris et al., 2002; Rego et al., 2013; Gronhøldt et al., 2000).

MATERIALS AND METHODS

This is an empirical study that ran for the five consequent years between 2013 and 2017. A total of 6,968 questionnaires concerning customer satisfaction were collected. An electronic questionnaire was used for the collection of the data for this specific research. The satisfaction criteria was based on the relevant literature concerning mobile communications customers' satisfaction, as follows (Krassadaki et al., 2002; Grigoroudis and Siskos, 2010; Drosos and Tsotsolas, 2014; Chalikias et al., 2016; Skordoulis et al., 2017; Drosos et al., 2018; Drosos et al., 2019; Drosos et al., 2020) : 1) Products-services: it refers to the satisfaction from products and services, 2) GSM network: it is the network of the mobile communications firm, 3) Stores: it refers to the location of stores and the network of branches that have been developed by the examined firms, 4) Human resources: it refers to the satisfaction from branches' or contacted centres' staff, 5) Customer service: it refers to consumer satisfaction from the services offered to them, 6) Prices: it focuses on the costs of services, 7) Webpage: it indicates the satisfaction from firms' websites. Furthermore, secondary data concerning Indices by the mobile communications firms were collected in order to examine the relationship between firms and customer satisfaction. These Indices are shown in Table 1.

Table 1: MARKET SHARE INDEXES

Market Share Indexes Based on	
Total Number of Prepaid Cards	Total Revenue from Retail Sales
Total Number of Contracts	Total Number of Outgoing Speech Minutes
Total Number of Active Subscribers	Total Number of Messages
Total Revenue from Retail Sales of Voice Services	Total Number of Subscribers
Total Revenue from Retail Data Services	Total Revenue

The correlation of customer satisfaction from business performance Indices was carried out using the statistical methods of the Spearman's rank correlation coefficient ρ and Linear Regression. The Multi-criteria Satisfaction Analysis (MUSA) method was used in order to measure customer satisfaction. The method is an ordinal-regression based approach used for the assessment of a set of collective satisfaction functions in such a way that the global satisfaction criterion becomes as consistent as possible with customers' judgments. In particular, the method infers an additive collective value function Y^* and a set of partial satisfaction (value) functions X_i^* , given customers' global satisfaction Y and partial satisfaction X_i according to the i -th criterion (ordinal scaling). The main objective of the method is to achieve the maximum consistency between the value function Y^* and the customers' judgments Y . Based on the modeling of preference disaggregation approach, the ordinal regression equation has the following form:

$$\begin{cases} Y^* = \sum_{i=1}^n b_i X_i^* \\ \sum_{i=1}^n b_i = 1 \end{cases} \quad (1)$$

Where \tilde{Y}^* represents the estimation of the global value function, n represents the number of criteria, b_i is a positive weight of the i -th criterion, σ^+ and σ^- are the overestimation and the underestimation errors, respectively, and the value functions Y^* and X_i are normalized in the interval $[0,100]$. The global and partial satisfaction Y^* and X_i^* are monotonic functions normalized in the interval $[0,100]$. Thus, in order to reduce the size of the mathematical program, the monotonicity constraints for Y^* and X_i^* were removed and the following transformation equations were applied:

$$\begin{cases} z_m = y^{*m+1} - y^{*m} & \text{for } m = 1, 2, \dots, a - 1 \\ w_{ik} = b_i(x_i^{*k+1} - x_i^{*k}) & \text{for } k = 1, 2, \dots, a_i - 1 \quad \forall i = 1, 2, \dots, n \end{cases} \quad (2)$$

where y^{*m} is the value of the y_m satisfaction level, x_i^{*k} is the value of the x_{ik} satisfaction level, and a and a_i are the number of global and partial satisfaction levels. According to the aforementioned definitions and the assumptions, the basic estimation model can be written in a linear program formulation, as follows:

$$\left\{ \begin{array}{l} [\min] F = \sum_{j=1}^M \sigma_j^+ + \sigma_j^- \\ \text{under the constraints:} \\ \sum_{i=1}^n \sum_{k=1}^{t_{ji}-1} w_{ik} - \sum_{m=1}^{t_j-1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \forall j = 1, 2, \dots, M \\ \sum_{m=1}^{a-1} z_m = 100 \\ \sum_{i=1}^n \sum_{k=1}^{a_i-1} w_{ik} = 100 \\ z_m, w_{ik}, \sigma_j^+, \sigma_j^- \geq 0 \quad \forall m, i, k, j \end{array} \right. \quad (3)$$

where M is the number of customers, n is the number of criteria, and x_i^{*j} , y^{*j} are the j -th level on which variables X_i and Y are estimated.

RESULTS AND DISCUSSION

Regarding the correlation between Global Satisfaction and Market Share Indicators, according to the results of Table 2, there seems to be a positive correlation but this is not statistically significant.

Table 2: Correlation Market Share Index and Global Satisfaction (Spearman's rho)

Market Share Indexes Based on	Customer Satisfaction	Market Share Indexes Based on	Customer Satisfaction
Total Number of Prepaid Cards	0,175	Total Revenue from Retail Sales	0,129
Total Number of Contracts	0,036	Total Number of Outgoing Speech Minutes	0,150
Total Number of Active Subscribers	0,096	Total Number of Messages	0,082
Total Revenue from Retail Sales of Voice Services	0,079	Total Number of Subscribers	0,182
Total Revenue from Retail Data Services	0,107	Total Revenue	0,118

** . Correlation is Significant at 0,01 Level (2 Tailed). * . Correlation is Significant at 0,01 Level (2 Tailed).

Based on the results shown in Table 3 there is a positive correlation between GSM network criterion satisfaction and the market share ratios. The highest statistically significant positive correlation appears in the market share index based on the total of retail sales revenue ($p = 0.732$). Also, in the market share index based on the total number of messages it appears to be a statistically significant positive correlation ($p = 0.533$).

Table 3: Correlation Market Share Indices and Satisfaction Criteria (Spearman's rho)

Indices \ Satisfaction Criteria	Products Services	GSM Network	Stores	Human Resources	Customer Service	Pricing Policy	Web Page
Total Number of Prepaid Cards	-0,107	0,389	-0,182	0,279	0,121	-0,029	0,046
Total Number of Contracts	-0,075	0,482	-0,036	0,189	0,154	-0,086	0,207
Total Number of Active Subscribers	-0,021	0,507	-0,075	0,236	0,179	-0,089	0,186
Total Revenue from Retail Sales of Voice Services	-0,089	0,425	0,021	0,207	0,175	-0,075	0,146
Total Revenue from Retail Data Services	0,318	0,732**	-0,046	0,161	0,139	-0,329	0,068
Total Revenue from Retail Sales	-0,025	0,489	0,021	0,200	0,168	-0,139	0,125
Total Number of Outgoing Speech Minutes	-0,039	0,482	-0,014	0,232	0,164	-0,154	0,089
Total Number of Messages	-0,009	0,533*	0,077	0,290	0,013	-,0245	0,127
Total Number of Subscribers	0,000	0,471	-0,111	0,304	0,204	-0,079	0,075
Total Revenue	-0,050	0,468	0,004	0,225	0,211	-0,089	0,139

** . Correlation is Significant at 0,01 Level (2 Tailed). * . Correlation is Significant at 0,01 Level (2 Tailed).

SUMMARY AND CONCLUDING REMARKS

Measuring customer satisfaction and correlating it with business performance is one of the most important factors in ensuring quality and economically viable businesses that make products or offer services. Thus, it is important for contemporary firms to use customer satisfaction as managerial indicator to obtain important information in measuring their performance. This information is of particular importance as it is directly or indirectly linked to the viability and the profitability of businesses. According to the survey results the utmost importance structural elements for company's viability, such as market share, they are positively related to measure customer satisfaction. The positive correlation solidifies the statement that the aforementioned philosophy is proven a modern tool of strategic planning for companies. Based on the research conducted and the results yielded, significant findings can be signified regarding the linkages between customer satisfaction and market share, taking into account elements such as employee satisfaction, employee loyalty, and customer loyalty.

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Development and implementation of a Methodological Framework for evaluating alternative sustainable urban mobility measures using Multi-criteria Analysis.

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Abstract

Since 2013, the European cities were encouraged to support the Sustainable Urban Mobility Policy by developing local Sustainable Urban Mobility Plans (SUMP). The specific planning procedure should follow the specific guidelines that was launched by DGMove in 2013 and was recently updated. The procedure is based on the "SUMP-Cycle" which specifies four phases and twelve steps of planning.

One of the most critical steps is the assessment of all the alternative measures and infrastructures, which will be proposed by the planning experts, in order to answer to the urban area needs and problems, serving also the determined vision and targets. The evaluation procedure should take into account the opinions of all the interested parties-stakeholders, scientific experts and public-through a cooperative and transparent procedure.

Many problems seem to have emerged during the implementation of the current evaluation process. Especially in countries like Greece, where such form of cooperative decision-making is not usual but also the culture of the stakeholders and citizens is not in favour of "environmentally friendly" mobility and of the corresponding measures and infrastructures, the choice of measures becomes even more difficult.

The aim of the proposed article is to present a methodological framework, which was designed for the Greek Authorities, who are currently developing their SUMP. The framework is based on the Multicriteria Analysis and is targeted to enhance the evaluation procedure of alternative measures and the ranking of them, based on the calculation of a Sustainable Efficiency Index (SEI) for each measure.

KEYWORDS

Multicriteria Analysis, sustainable mobility, urban planning, mobility measures.

INTRODUCTION

The planning of the urban transport in a more sustainable and human centric philosophy is an integral part of the overall urban planning processes that currently are taking place in modern cities [10]. Their main idea is based on the minimization of the urban/network space, which is given to the private vehicles, construction of infrastructures for public transport, walking and biking, development of new transport schemes such as bike or car sharing systems etc. These new ways of urban trips are going to significantly influence many aspects of the quality of life in cities such as residents' health, safety, economic and developmental opportunities, as well as conditions of work and leisure.

It becomes clear that the role of Sustainable Urban Mobility Plans, charging schemes and urban logistics are pivotal for the development of sustainable urban mobility systems throughout the EU, while the international dimension should also be taken into consideration.

For answering the need of the cities for more instructions as regards the sustainable urban mobility planning, a first version of Guidelines for Sustainable Urban Mobility Planning was published in late 2013 by DG Move. A number of 1168 of planning practitioners and other experts from all over Europe had contributed to a comprehensive consultation for the definition of this new planning concept. In parallel, the European Commission had systematically developed its

urban mobility policy and published its Urban Mobility Package that included a definition of the concept of “Sustainable Urban Mobility Plans” [8].

Six years later major new developments in many areas of urban mobility took place. New technologies, driverless electric vehicles, new business models provided “Mobility as a Service”, shared mobility and cycling. As a result, an update of the original SUMP Guidelines was published in the end of 2019 [9].

The updated SUMP Guidelines, offer concrete suggestions on how to apply the SUMP concept and prepare an urban mobility strategy that builds on a clear vision for the sustainable development of an urban area. This process of developing and implementing a SUMP is defined into 4 main phases and 12 main steps as it is presented in the so called “SuMP Cycle”.

There are many decisions during the sump process, so different parameters should be taken into account. The selected strategy that will be followed in order to serve the vision of the city, the targets of the city future development, the selected measures and infrastructures that are going to achieve these targets but are also feasible to be realized in the specific time limits.

In these circumstances, the cost-benefit analysis (CBA) method, which is based on the calculation of the cost of infrastructure construction, operation and maintenance on the one hand, and benefits on the other (social, environmental etc), has certain limitations. These are primarily related to how impossible it is to adequately valorise alternative solutions in urban areas in terms of their specific impact on the environment or community through calculation in monetary values [10].

The SUMP cycle methodology, demands in many steps, the ex-ante evaluation of measures and infrastructures taking into account specific criteria such as the time for their realization, their effect to the vision and targets that were set, the institutional and legal complexity for their implementation/operation as well as the overall cost and funding opportunities. This evaluation must take into account the opinion of the stakeholder and relevant authorities but also the citizens.

In order to improve the decision-making process under such complex circumstances, it is important to apply new tools that target on raising the level of transparency and objectivity of the solution selection process. Multi-criteria analyses (MCA) are nowadays broadly used to find solutions to complex problems, such as those relating to the selection of mobility infrastructures and measures in urban areas.

The aim of the article is to present a methodological framework and some initial results, which was designed for the Greek Authorities, who are currently developing their SUMP. The framework is based on the Multicriteria Analysis and is targeted to enhance the evaluation procedure of alternative measures and the ranking of them, based on the calculation of a Sustainable Efficiency Index (SEI) for each measure

DEVELOPING THE METHODOLOGICAL FRAMEWORK FOR EVALUATING ALTERNATIVE SUSTAINABLE URBAN MOBILITY MEASURES

The PROMETHEE methodology

In recent years, various Multi-Criteria Decision Analysis (MCDA) methods have been proposed to help in selecting the best alternative compromise solutions. The development of MCDA methods is motivated not only to solve real problems that require multiple criteria but also to the desire of professionals to propose improved decision-making techniques using recent developments in mathematical optimization, computer science and computer technology (Wiecek et al., 2008).

The PROMETHEE method (method of ranking preferences for enrichment ratings) is one of the most well-known and widespread MCDA methods. These methods were developed by Brans (1982) and further extended by Vincke and Brans (1985). PROMETHEE is a method of extrovertly addressing a finite set of alternative actions that need to be classified and ranked based on specific criteria, which are often conflicting. PROMETHEE is also a simple method of classification and application compared to other methods for multi-criteria analysis (Brans et al., 1986).

Therefore, the number of professionals using the PROMETHEE method in practical multi-criteria decision-making problems and researchers who are interested in the PROMETHEE sensitivity aspects are increasing every year, as shown by the increasing number of scientific papers and conferences presentations.

The step by step implementation of the PROMETHEE methodology guided the development of the methodological framework for evaluating alternative sustainable mobility measures using the efficiency index as it is analytically described in the next session.

The evaluation framework.

The main target of the methodological framework is to use Multicriteria Analysis in order to easily rank and evaluate a list of measures that most of the cities use to adopt in their SUMP, taking into account the opinions of different experts on sustainable mobility planning (stakeholders and relevant engineers).

The methodology is based on the calculation of the sustainable efficiency index (SEI) for each proposed measure. For this calculation, specific weight should be given as a first step, to each policy objective that will be served by the SUMP implementation. For the proposed methodology these main objectives are the Accessibility and Operation of the Transport System, the Environment, the Society, the Economy and the Transportation system quality.

However, apart from these objectives, a very crucial parameter for the successful implementation of the SUMP measures is the easiness of application as regards the institutional interactions, the authorization of the SUMP owner to implement these measures, legal barriers and difficulties for finding funding opportunities etc. For this reason, weight should be given also to the specific parameter so called Easiness of Implementation (Institutional Interactions/Funding opportunities).

For each one of the above objectives, specific result indicators have been determined. So, as a second step, the weight of each result indicator should be evaluated, answering to the question: "how much does each indicator contribute into bringing the city closer to its specific vision of sustainable mobility and development?" These indicators per objective are presented in the table1 below.

The third step of the methodology, regards the evaluation of the intensity with which, each measure affects the result indicators of the policy objectives while the fourth step regards the evaluation of the intensity with which, each measure affects the result indicators of the easiness of the application. For the pilot implementation of the methodology and based on the selection of measures that so far seems to be mainly proposed and adopted by the Greek Authorities who implement their SUMP, specific measures were selected for evaluation as presented in the table 2 below.

The fifth step of the methodology regards the application of the PROMETHEE multicriteria analysis, which will calculate separately the multicriteria preference degree of the measures, to the policy and easiness objectives, separately.

Finally, the sixth step of the framework combines the results of the PROMETHEE analysis with the weight given to each objective in order to calculate the sustainable efficiency index (SEI) for each proposed measure.

The current methodological framework was used to collect opinions of experts from the technical staff of Greek Municipalities and transportation planning engineers. The main characteristics on both of the groups is their experience in developing and implementing SUMP. The main results of the framework as regards the weight of each policy objective including easiness to implement (step 1) and each result indicator (step 2) as well as the ranking of measures according to the result and the easiness to implement indicators preference degree (step 5) are presented in the tables 3,4 and 5 below.

Table 1: Result indicators per objective.

OBJECTIVES	RESULT INDICATORS
Accessibility	Increase in the number of kilometers carried out by bicycle
	Increase in the number of kilometers carried out by Public Transport
	Increase in pedestrian kilometers
	Reduction of travel time between specific O-D pairs carried out on foot.
Society	Reduction of the travel time between specific O-D pairs carried out by bicycle.
	Reduction of the average walking distance to / from the bus stops for specific O-D pairs.
	Reduction (%) of dead and seriously injured in road accidents within the urban network
Environment	Reduction of social exclusion due to low accessibility in transport services of people with mobility problems
	Reduction (%) of CO2 and NOx emissions caused by traffic
Economy	Reduction (%) of noise emissions caused by traffic
	Increase of new jobs
Transportation system quality	Contribution of measures to the various economic sectors of the city (tourism, entrepreneurship, etc.)
	Upgrading the quality of the Public Transport system
	Upgrading the offered quality of bicycle infrastructures
Easiness of Application / Interactions	Upgrading the quality of infrastructure offered for walking.
	The institutional responsibility for the implementation of the measures exclusively belong to the Municipality or there is a need for cooperation with other bodies.
	Interaction of the measure with other measures or infrastructures that need to be implemented before.
	Legal and institutional barriers that need to be solved for implementing the current measure.
	Total investment amount.
	Opportunities to include the project in European, national or regional funding schemes or capability to be financed by own resources.

Table 2: Measures that were selected for evaluation.

	MEASURES
1	Development of a shared system of Electric and Conventional Bicycles as well as small-capacity electric cars.
2	Redesign of the existing Public Transport system.
3	Introduction e- bus line by the operator of the existing Public Transport System.
4	Development of a new high frequency municipal e-bus line,
5	Conversion of central commercial axis of the city to a 3 km long pedestrian walkway with open spaces for the citizens and infrastructures for biking and recreation areas.
6	Conversion of the main commercial axis into a light traffic road, with exclusive access to buses, taxi, electric vehicles, bicycles, and many open spaces for pedestrians.
7	Conversion of a municipal open space to a central bioclimatic park with recreation areas, cultivation, thematic parks etc.
8	Development of a high technology traffic and parking monitoring, and management center offering real time traffic information and routing services to the citizens (web or mobile app).
9	Implementation of infrastructures and creation of incentives to promote e-mobility. Installation of electric vehicle charging stations in several axis of the urban network and in off-road parking stations of the city center. Reduced cost of on-road parking.
10	Implementation of infrastructures for enhancing the mobility of people with disabilities.

Table 3: Weights per result indicator, easiness to implement and policy objectives

Result Indicator	Weight	Result Indicator	Weight	Easiness to implement	Weight	Policy Objective	Weight
2	10,09	14	6,91	3	23,64	3	23,64
7	8,36	6	6,36	2	20,91	2	20,91
4	8,09	9	5,64	5	20,91	5	20,91
15	7,64	12	5,36	4	17,73	4	17,73
3	7,45	10	5,09	1	16,82	1	16,82
8	7,45	11	4,45				
13	7,00	5	4,18				

Table 4: Ranking of the measures according to the easiness to implement indicators preference degree

	Measure	Phi	Phi+	Phi-
1	Measure3	0,3446	0,5607	0,2161
2	Measure5	0,2954	0,5622	0,2669
3	Measure4	0,2342	0,504	0,2698
4	Measure 6	0,17	0,5035	0,3336
5	Measure2	0,1476	0,4556	0,308
6	Measure7	0,0565	0,4733	0,4168
7	Measure8	-0,1381	0,3775	0,5156
8	Measure1	-0,2435	0,3023	0,5458
9	Measure10	-0,3104	0,2743	0,5848
10	Measure9	-0,5563	0,172	0,7282

Table 5: Ranking of the measures according to the result indicators preference degree

	Measure	Phi	Phi+	Phi-
1	Measure9	0,12	0,3976	0,2777
2	Measure1	0,1167	0,3802	0,2635
3	Measure7	0,1027	0,3572	0,2545
4	Measure5	0,0665	0,3292	0,2627
5	Measure8	0,0614	0,3416	0,2803
6	Measure3	0,0245	0,334	0,3096
7	Measure4	-0,0412	0,2941	0,3353
8	Measure2	-0,1115	0,2853	0,3968
9	Measure10	-0,1649	0,247	0,4119
10	Measure 6	-0,174	0,2329	0,4069

CONCLUSIONS

The new form of Urban Mobility Planning aims to have a sustainable impact not only to the transport and environment but also to the society the economy and the policy of the study area. The above-mentioned prerequisites, led to the use of Multicriteria Analysis, for implementing the methodological framework which is presented in the current work. The current framework, is based on the calculation of the sustainable efficiency index (SEI) for each proposed measure of a plan, using specific weights. After the evaluation of the intensity with which, each measure affects the result indicators and the final calculation of the index, the ranking of all the measures enables the decision of the authorities as regards the groups of measures that can be implemented per time horizon.

The application of the specific framework to a large list of relevant authorities could create a dedicated list of weights and a specific ranking of measures. Analysis of differentiations between different planning areas characteristics or

profile of experts will be interest to be further explored. A very important step for continuing and upgrade the above presented methodology will be to include more criteria in the current methodology and analysis. The use of the PROMETHEE for selecting alternative strategies, infrastructures, measures or policies can be enriched with the introduction of more weighted criteria (additional to the priorities) as regards the comparative costs, the ease of implementation or even the necessary institutional framework that must take place for the implementation of any of these alternatives.

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Session 3: Business Process Management

chair: Kostas Vergidis

A systematic investigation of the main variables of the Business Process Optimisation problem

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Abstract

Business process optimisation (BPO) is one of the key research areas that provide a formal perspective of the concept of business processes and signifies the automated improvement of BPs using pre-specified measures of performance (objectives). The importance of BPO lies in the ability to evaluate and compare alternative BP designs based on quantitative evaluation criteria, towards the selection of optimal solutions. The approach, presented in this paper, builds upon an evolutionary multi-objective business process optimization framework (bpo^F), that utilizes BP representation through the Process Composition Algorithm (PCA) and Evolutionary Multi-objective Optimisation Algorithms (EMOAs) to generate alternative optimized designs. This paper revisits the bpo^F by conducting an extended and systematic investigation of the BPO problem variables, through the employment of the statistical approach Design of Experiments (DOE). By employing a series of scalable tests, the variables of bpo^F, were examined to determine their limits and the application of DOE conducted to the analysis and interpretation of the results. The principal contribution of this approach is the exploration of the problem variables that refer to structural aspects of the business process model and have a significant influence on the results. What is also demonstrated is the influence magnitude of each variable and the involvement proportion on the result formation.

KEYWORDS

Business Process Optimisation, business processes, Design of Experiments.

INTRODUCTION

A *business process* (BP) is perceived as a collective set of tasks that when properly connected perform a business operation (Georgoulakos et al., 2017). Business process optimisation (BPO) on the other hand is one of the key research areas that provide a formal perspective towards the concept of BPs, and signifies the automated improvement of BPs using pre-specified measures of performance (objectives) (Tsakalidis and Vergidis, 2017). The importance of BPO lies in the ability to (re)design a BP based on quantitative evaluation criteria (Tsakalidis et al., 2019). This concept stresses the need for alternative BP designs to be quantitatively evaluated and compared. It also offers the advantage of generating various designs based on the same process requirements. For complementing and extending BPO techniques there is a plethora of statistical techniques such as Design of Experiments (DOE), Response Surface Methods (RSM), Bayesian methods for process optimization, Stochastic Approximation, Kriging methods and “computer experiment” techniques (Castillo, 2007). The advantages from adopting a statistical approach to BPO practice are multiple, e.g. to investigate the relationship between the quality characteristics and factors, build the optimization model and determine the optimal parameters to obtain the best quality characteristics of BPs in the end (Zhao et al., 2012). The approach presented in this paper builds upon an evolutionary framework (Vergidis et al., 2012), by: (a) systematically investigating the BPO problem variables through the employment of a series of scalable BP test problems, and most importantly (b) applying the statistical approach DOE in the BPO problem. This approach also provides the necessary tools to analyze and interpret the optimisation results and strategies to design an experiment and collect data. The remaining of this paper is structured as follow: section 2 presents the initial experiments for the main problem variables, section 3 introduces the variables characterization using DOE, and, section 4 provides the discussion and conclusions section where the main contributions of the presented approach are highlighted.

INITIAL EXPERIMENTS FOR THE MAIN PROBLEM VARIABLES

The authors focus on the main problem variables of the evolutionary multi-objective optimisation framework for business process designs (bpo^F) presented in ((Vergidis et al., 2012), (Vergidis et al., 2015)) and elaborated in (Georgoulakos et al., 2017). Since a systematic statistical approach for the investigation of the BPO problem variables is absent in literature, the authors implement DOE towards achieving the full potential of the BPO framework. The framework applies state-of-the-art EMOAs to given business process requirements to: (i) compose feasible designs utilizing a library with multiple candidate tasks, and, (ii) locate the optimal solutions based on multiple criteria. For each candidate task in the library, there are p available measurable (quantitative) performance indicators, i.e. task attributes

such as task execution cost and task duration. The task attributes are mapped to corresponding process attributes (e.g. process cost) using aggregate functions that form the optimisation objectives. The available resources are assimilated based on the input and output resources of all candidate tasks in the library. The nature and the type of the resources are not taken into account in this work. The task resources connect the tasks, forming the process design. Also, the resources shape the requirements for a process design by denoting the required process input and expected process output. A feasible business process design is one that starts with the resources and by properly connecting available tasks produces the requested output resources. After producing a set of feasible business process designs, the process attribute values are calculated for each design based on aggregate functions. Each process attribute can either be subjected to maximization or minimization depending on its nature. The bpo^F (Vergidis et al., 2012) aims at locating the designs with the optimal process attribute values.

Given the problem formulation, design composition and optimisation, this is not a typical problem of optimizing a series of objective functions given the constraints. It is a discrete problem, as the main variable is a set of tasks (N_d) that form the business process design. In addition to the discrete nature of the problem, we have assumed a multi-objective nature and assuming that the participating objectives are conflicting, then each solution represents a different trade-off between the objectives. For the constraints to be checked, the framework employs an algorithmic procedure (PCA) before the objective functions (i.e. process attribute values) can be calculated for a feasible solution. As a result, the EMOAs employed by the framework have a series of challenges to address to generate the Pareto optimal front of solutions across all of the objectives. The discrete nature of the problem in conjunction with its multi-objective formulation can make the process of discovering feasible solutions very challenging for the algorithms, even for problems with a small number of tasks in the process design thus there is a need to investigate the boundaries of the problem using a systematic approach. The research questions posed in (Vergidis, 2008) dealt with: (i) the maximum size of a business process design (n_d) that can be optimized, (ii) how the minimum number of tasks (n_{min}) in a business process design affects the population of feasible and optimized solutions, and (iii) the minimum library size (n) that the framework can operate with. Due to the fact that the investigation proved inconclusive, the need for further investigation motivated the authors to investigate the boundaries of these problem variables and to subsequently construct a methodology for generating scalable problems of varying difficulty for testing thoroughly the bpo^F . The strategy devised for the determination of the variable boundaries is based on the experimental approach employed in the bpo^F performance evaluation (Vergidis, 2008). The authors performed a series of scalable tests to determine the values of the n (number of tasks in the library), the r (number of available resources) and the n_d (number of tasks in the design) that the bpo^F produces consistent optimal solutions. In these experiments, the variables were combined in a scalable manner to determine the combinations that produce consistent results. Initially, the tests focused on the determining the boundaries of n and r while the n_d remained constant. Subsequently, utilizing the findings from the first series of tests, the authors experimented with the actual process size (n_d). Table 1 shows the combinations of the two main variables, i.e. number of tasks in the library and available resources. The n_d variable is fixed to ten tasks as this process size is the most common for designs being investigated in this scenario.

Table 1 Variable combinations for library size (n) and available resources (r)

		r								
$n_d = 10$		10	15	20	25	30	35	40	50	60
n	30	0	10	-	3	0	-	-	-	-
	100	0	9	-	10	8	3	3	0	-
	125	-	0	8	-	5	3	3	0	-
	150	-	0	0	3	4	7	2	1	0
	175	-	-	6	-	5	4	3	0	-
	200	-	-	0	0	7	0	-	-	-

Table 2 Upper and lower limits for the available resources (r) given the library size (n)

		r								
$n_d = 10$		10	15	20	25	30	35	40	50	60
n	30	lower			upper					
	100	lower						upper		
	125							upper		
	150				lower			upper		
	175	lower						upper		
	200				lower			/upper		

The starting point of the investigation for the n variable is the thirty tasks ($n=30$). This value is selected as the minimum number of available tasks to exist in the library. The starting point of the investigation for the r variable is the ten resources ($r=10$). This value can be considered as a minimum number of available resources that the library can have in order for the bpo^F to generate optimized designs. An experiment deems failed in the case that the bpo^F does not generate any solutions. Also, if a particular r value does not generate solutions for two consequent values of the n variable, then no further experiments are performed. Based on the initial experiments, the variable combinations are shown in Table 2. Regarding the n_d variable, the authors selected two starting points to investigate its lower and upper value by employing the boundaries of the n, r variables extracted from the initial experiments. Table 3 presents the tests that are generated for the second part and their results. As it was mentioned, a test was terminated when the bpo^F did not generate solutions for a value of n_d variable. However, in some tests the bpo^F generated solutions for all the n_d variable values but the tests were terminated in the n_d value equal to four. This happened because a process size with four tasks ($n_d=4$) can be considered as the minimum size for this type of designs. Also, the final test was terminated in the n_d value equal to forty, because for three n_d values in a row the bpo^F did not generate satisfactory results. From the results that are presented above, we conclude that the n_d variable values for which the bpo^F generates consistent results are:

- For $n=30$ and $r=15$, values of n_d variable in the space $n_d = [5,12]$
- For $n=200$ and $r=30$, values of n_d variable in the space $n_d = [5,25]$

Table 3 Tests and results

n	r	n_d													
		9	8	7	6	5	4	11	12	13	20	25	30	35	40
30	15	12	7	8	10	6	2	6	5	0	-	-	-	-	-
30	25	1	2	2	0	-	-	0	-	-	-	-	-	-	
200	30	5	5	4	4	5	2	4	6	6	3	5	2	1	1

VARIABLE CHARACTERIZATION USING DOE

This section aims at characterizing the BPO problem variables using DOE which is a vital optimization tool to optimize the business process and acquire the best solution in the classical lean six sigma theory (Lin and Zhen, 2007). According to the classical lean six sigma theory, the methods of DOE include (a) orthogonal experimental design, (b) response surface design and (c) factorial design, which can be divided into fractional factorial design and complete factorial design. The expectations of employing DOE for the BPO problem are to determine:

- the effects of the variables (i.e. the change in the number of solutions that the bpo^F generates when a variable changes from a value to another),
- the effect magnitude,
- how likely these effects are to be important, and
- a potential interaction between the variables (i.e. the change in the number of solutions that the bpo^F generates when a variable changes from a value to another is to depend on the value of another variable).

Following the guideline that Montgomery (Montgomery, 2017) proposed for DOE and based on the results that are presented on the previous section, the authors used the 2^3 factorial design in order to study the three specific bpo^F variables that was mentioned before. The 2^3 factorial design was selected because it provides the smallest number of runs with which factors can be studied. Moreover, the calculation of the magnitude, the direction of factor effects and their interactions, is feasible. Employing the DOE terminology, factors are the bpo^F variables and levels are the values that a variable can take. During our study the experiment accounts for the bpo^F execution and the data that have to be collected or the measurements that need to be recorded account for the solutions that are generated by the bpo^F . The authors utilize the NSGA2 and its variables are set constant in all tests, i.e. (a) Population = 500, (b) Generations = 25,000, (c) Crossover prob. = 0.8 and (d) Mutation prob. = 0.2. Table 4 presents the measurements that were conducted in order to study and characterize the factors of BPO problem.

Table 4 Sample of BPO solutions

Run	Factor			Solutions			
	<i>n</i>	<i>r</i>	<i>n_d</i>	Replicate1	Replicate2	Replicate3	Replicate4
1	30	15	8	8	6	8	7
2	100	15	8	8	11	7	11
3	30	25	8	2	2	1	1
4	100	25	8	9	7	10	7
5	30	15	10	8	9	11	10
6	100	15	10	7	10	9	8
7	30	25	10	2	2	1	1
8	100	25	10	10	10	5	7

In the table each run expresses an execution of bpo^F in which the factors of the business process problem are in the displaying levels. In addition, each run is repeated four times or according to the DOE terminology four replications are performed and the solutions that were generated by bpo^F are shown in the respective cells. This number of replications considered enough in order to have a good estimation of the factor effects. Also, there were not being any restrictions. The statistical analysis relies on the Minitab statistical software and ultimately characterize the factors. The estimated factors effects along with their P-values are shown in Table 5 and Table 6 presents the ANOVA. The significance level is defined to be 5% ($\alpha = 0.05$) so a P-value of less than 0.05 (<0.05) implies significance. In Table 6, the sign ‘-’ indicates that the number of solutions is reduced while the factor changes from the low level to the high level. The terms with the sign ‘*’ express the interactions of the factors. Finally, the *P-value cannot be equal to zero*, but Minitab expresses the very small values ($< 0,0001$) in this way. As it seems in both tables there are three effects that can be characterized as highly significant due to the fact that their P-values are very small. These effects are:

- the effect of *r* factor
- the effect of *n* factor
- the interaction between *n* and *r* factors.

Based on the ANOVA, the variability in the data can be explained by the quantity R-squared that was calculated equals to: $R^2 = \frac{SS_{Model}}{SS_T} = 0,8534$

The R-squared indicates that the factors *n*, *r*, *n_d* and their interactions involve to the result formation by up to 85,34 %.

Table 5. Factors effects

Term	Effect	P-Value
<i>n</i>	3,562	0,000
<i>r</i>	-3,813	0,000
<i>n_d</i>	0,312	0,555
<i>n</i> * <i>r</i>	3,062	0,000
<i>n</i> * <i>n_d</i>	-0,813	0,132
<i>r</i> * <i>n_d</i>	-0,438	0,410
<i>n</i> * <i>r</i> * <i>n_d</i>	0,688	0,200

Table 6. ANOVA table

Source	DF	SS	MS	F-Value	P-Value
Model	7	304,219	43,460	19,96	0,000
Linear	3	218,594	72,865	33,47	0,000
<i>n</i>	1	101,531	101,531	46,64	0,000
<i>r</i>	1	116,281	116,281	53,41	0,000
<i>n_d</i>	1	0,781	0,781	0,36	0,555
2-Way Interactions	3	81,844	27,281	12,53	0,000
<i>n</i> * <i>r</i>	1	75,031	75,031	34,46	0,000
<i>n</i> * <i>n_d</i>	1	5,281	5,281	2,43	0,132
<i>r</i> * <i>n_d</i>	1	1,531	1,531	0,70	0,410
3-Way Interactions	1	3,781	3,781	1,74	0,200
<i>n</i> * <i>r</i> * <i>n_d</i>	1	3,781	3,781	1,74	0,200
Error	24	52,250	2,177		
Total	31	356,469			

DISCUSSION AND CONCLUSIONS

This paper contributes to the bpo^F framework by providing an extended investigation of the BPO problem variables, through the employment of the DOE statistical approach. To accomplish this, the authors performed a series of scalable

business process tests and determined (a) the variable values for which the bpo^F generates consistent results and as a result the variable limits, (b) the variables that have a significant influence on the results that the bpo^F generates, the variable that has the biggest influence and (c) the magnitudes of these influences. Also, the authors ascertained the involvement proportion of n , r , n_d variables on the result formation that the bpo^F generates. What is deduced from the identification and analysis of the main contributors and their interactions, is that an effective way to cope with experimental variation is a systematic investigation. In total the application of DOE to the BPO problem variables provides the necessary tools to analyze and interpret the optimisation results, and at the same time constitutes a systematic strategy for designing an experiment and collecting data.

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Towards a comprehensive design of BPM lifecycle: The notion of core cycle-steps (CSS)

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Abstract

There is a plethora of approaches towards composing a Business Process Management (BPM) lifecycle and the established attempts bear varying issues and limitations; namely the multitude of included cycle steps and their irresolute positioning in the lifecycle. Most of the BPM lifecycles consist of a set of defined cycle steps (e.g. Identification, Modeling, Analysis, etc.). These steps represent discrete BPM phases that are identified and placed in a specific order (forming a “lifecycle”) so that they can effectively cater an organization’s business processes. However, this notion has inherent issues that have resulted in a significant variety of BPM lifecycles with disparate combinations of cycle steps. The authors examined and located the most popular BPM lifecycles in literature, narrowing for studies on BPM lifecycles from 2000 until 2017, and located twelve lifecycles that are highly cited. This paper introduces the notion of core cycle steps (CCS) of the selected BPM lifecycles. CCS are cycle steps that describe a single BPM phase following a standardized naming convention. The CCS emerged from the aggregate processing of all the cycle steps of the examined BPM lifecycles. The aim of producing the CCS is to better study and evaluate: (a) their importance, i.e. why they are selected for inclusion in a BPM lifecycle), (b) their placement, i.e. their specific positioning in each lifecycle, and, (c) their associations, i.e. their relevance to their precedent and antecedent steps across the various lifecycles. By examining these traits, a comprehensive BPM lifecycle is put forward with justification of the cycle steps that are included and their positioning in the lifecycle.

KEYWORDS

Business Process Management, business processes, lifecycle, models, core cycle-steps

INTRODUCTION

Business process management (BPM) represents a vital discipline of businesses, enterprises and organizations, due to the direct impact it begets towards the attractiveness of products and services. The adoption of business processes proved to be a critical strategy towards business digitalization. The last two decades the development of tools, techniques and methodologies allowed BPM to provide support for all phases of a business process lifecycle. While BPM was evolving over the years a big question arose as to “*What is the best sequence of steps that someone needs to apply in order to continuously improve a business process?*”. At that time the term business process management lifecycle appeared. Business process management lifecycle is a set of methods, techniques, and tools for handling business processes (i.e. modeling, execution and analysis) of an organization (Weske, 2007). These processes are organized in phases that consist of discrete cycle steps. BPM lifecycles are continuous (Ma and Leymann, 2008) and composed of activities (Van Der Aalst, 2003). However, there are multiple variations and convergences both to the lifecycles in general and the cycle steps throughout literature. The authors examined and located the most popular BPM lifecycles in literature, narrowing for studies on BPM lifecycles from 2000 until 2017, and located twelve lifecycles that are highly cited. As we stated before those lifecycles had many variations and similarities. Moreover they emphasized in different aspects of a business process. In this paper the scope of these lifecycles will be identified and their cycle steps will be analyzed in order to be broken down to simple and comprehensible steps, i.e. the core cycle steps (CCS).

RELATED WORK

This section illustrates the plethora of approaches towards sketching a BPM lifecycle and focuses on the issues and challenges that arise from these established attempts; namely the multitude of included cycle steps and their irresolute positioning in the lifecycle. To examine and locate the most popular BPM lifecycles in literature, the authors conducted a review and selection process, narrowed for studies on BPM lifecycles from 2000 until 2017. The authors located twelve lifecycles that are highly cited and introduced by the most influential researchers in the field. The selected lifecycles are discussed in regards to the cycle steps they incorporate (Table 1).

Table 1. Selected BPM Lifecycles and their respective cycle-steps

Lifecycle	1	2	3	4	5	6	7
ABPMP, 2009	Process Planning & Strategy	Analysis of Business Processes	Design & Modelling of Business Processes	Process Implementation	Process Monitoring and Controlling	Process Refinement	
Bernardo et al., 2017	Identify New Market Opportunities and Changes	Initial Process of Planning and Strategy	Analysis of Business Process	Design and Modeling of Business Process	Process Implementation	Process Monitoring and Controlling	Process Refining and Planning Review
Macedo de Morais et al., 2014	Initial Process Planning and Strategy	Analysis of Business Process	Design and Modeling of Business Process	Process Implementation	Process Monitoring and Controlling	Process Refinement and Planning Review	
Dumas et al., 2013	Process Identification	Process Discovery	Process Analysis	Process Redesign	Process Implementation	Process Monitoring and Controlling	
Hallerbach et al., 2008	Modeling	Instantiation/ Selection	Execution	Optimization			
Houy et al., 2010	Strategy Development	Definition and Modeling	Implementation	Execution	Monitoring and Controlling	Optimization and Improvement	
Netjes et al., 2006	Design	Configuration	Execution	Control	Diagnosis		
Schulte et al., 2015	Evaluation	Design & Analysis	Configuration	Enactment	Evaluation		
Van Der Aalst et al., 2003	Process Design	System Configuration	Process Enactment	Diagnosis			
Verma, 2009	Define Organization Objectives	Classify Processes	Select n-th Process	Define Tools	Implement Process	Monitor Process	
Weske, 2007	Design & Analysis	Configuration	Enactment	Evaluation			
Zur Muehlen and Ho, 2005	Goal Specification/ Environmental Analysis	Process Design	Process Implementation	Process Enactment	Process Monitoring	Process Evaluation	

Despite the fact that the presented BPM lifecycle models serve their particular purpose and each one contributes differently to the BPM field, some important issues aroused during the conducted review. In specific, there is a variety of approaches that may cause confusion or mislead practitioners. Other lifecycle models bear slight differences with each other, despite the fact that they are designed with different orientation, or for different applications. What the authors also deduced is that the reviewed lifecycle models are relatively static and simplistic and at the same time a comprehensive description of the interrelations of each model's steps is missing. Moreover many cycle steps develop from the merging of two separate steps (e.g. Process Monitoring and Controlling) while other steps have different labels in spite of the fact that they stand for the same step (e.g. Diagnosis and Evaluation). Lastly, a significant issue is that the selected lifecycle models do not follow a standard modeling approach or depiction methodology, a fact that conduces to the plenitude and variance of model schemas.

THE NOTION OF CORE CYCLE-STEPS

The analysis of a BPM lifecycle model involves the consideration of the cycle steps it includes. Moreover a critical characteristic of a lifecycle model is the associations between these steps and the particular sequence they appear in. The introduction of a consistent and integrated BPM lifecycle model requires the comprehension of the context of each cycle step and the interrelation between the varying steps. Following the review and analysis of each BPM lifecycle model, the authors isolated the cycle steps of each model. From all the proposed life cycle steps, the authors decided to leave aside "Adjustment of organizational resources" and "Validation of Strategic Planning" steps in Bernardo et al. (2017) model, because these two steps refer to the determination of an organization's resources and strategic direction and do not associate with the steps that need to follow to manage an organization's business process. It is evident by now that each of the selected BPM lifecycles, consists of a set of defined cycle steps (e.g. "Identification", "Modeling", "Analysis", etc.). These steps represent discrete BPM phases that are identified and placed in a specific order (forming

a lifecycle) so that they can effectively cater an organization’s business process. However, this notion has inherent issues that have resulted in a significant variety of BPM lifecycles with combinations of cycle steps. The issues with the existing cycle steps are:

- i. The naming convention is generic and sometimes oversimplified (i.e. “Control” in Netjes et al. model), thus not adequately communicating the functionality and necessity of the step.
- ii. The placement of each cycle step in the lifecycle is not adequately justified resulting in different placements of the same or similar cycle steps in the various lifecycles (i.e. “Analysis” is initial step in Weske’s model, and third in sequence step in ABPMP’s model). As a result, there is not a BPM lifecycle with convincing justification of its selected cycle steps and their specific ordering.

To address the above issues, this section introduces the notion of *core cycle steps (CCS)* of the BPM lifecycles. CCS are cycle steps that describe a single BPM phase following a standardized naming convention. The CCS emerged from the aggregate processing of all cycle steps of the selected BPM lifecycles. The aims of producing the CCS is to better study and evaluate: (a) their *importance*, i.e. why they are selected for inclusion in a BPM lifecycle, (b) their *placement*, i.e. their specific positioning in each lifecycle, and, (c) their *associations*, i.e. their relevance to their precedent and antecedent steps across the various lifecycles. By examining these traits, an ordered BPM lifecycle can be put forward with justification of the cycle steps that are included and their positioning in the lifecycle. To identify and process the CCS, we followed a series of steps: (a) Naming convention and normalization, (b) Calculation of the frequency of occurrence and (c) Identification of the degree of association.

In the various lifecycles, there is no coherent naming convention for the cycle steps and often two individual steps are merged into one in an attempt to reduce the overall cycle steps (e.g. “Design and Modeling” in ABPMP lifecycle). The aim of the naming convention normalization is for every CSS to reflect one -clearly defined- step only. The following guidelines were applied across the selected BPM lifecycles:

1. The word ‘process’ is removed from the cycle steps to ensure consistency across all the CCS (e.g. “process discovery” is renamed “discovery”).
2. Each cycle step that contains two or more phases was separated (e.g. “Design & Modeling” ABPMP is split to “Design” and “Modeling”, “Instantiation/Selection” in Hallerbach et al. lifecycle is split to “Instantiation” and “Selection”).
3. The cycle step “Process Planning & Strategy” in ABPMP lifecycle follows both guidelines and it is transformed to “Planning” and “Strategy” steps.

This processing of cycle steps resulted to the identification and normalization of 22 uniform CCS across the lifecycles, as shown in Table 2.

Table 2 Frequency of occurrence for the CCS

Core Cycle-Steps (CCS)		Frequency of occurrence	Appearance in lifecycles
DES	Design	8	66,7%
ANA	Analysis	7	58,3%
IMP	Implementation	7	58,3%
MON	Monitor	7	58,3%
CON	Control	6	50,0%
MOD	Modeling	5	41,7%
STR	Strategy	4	33,3%
SC	System Configuration	4	33,3%
EN	Enactment	4	33,3%
ID	Identification	3	25,0%
PLA	Planning	3	25,0%
EXE	Execution	3	25,0%
EVA	Evaluation	3	25,0%
REF	Refinement	3	25,0%
DEF	Definition	2	16,7%
SEL	Selection	2	16,7%
DIA	Diagnosis	2	16,7%
OPT	Optimization	2	16,7%
PR	Planning Review	2	16,7%
DIS	Discover	1	8,3%
INS	Instantiation	1	8,3%

After creating the CCS the next stage involves counting the number of occurrences of the 22 individual CCS across the lifecycles. The frequency of appearance is directly related to their importance as a step of a BPM lifecycle, due to the fact that more authors chose to include it in their mappings of BPM lifecycles. Table 3 also exhibits the aggregate frequency of occurrence of the identified CCS across the lifecycles.

DEGREE OF ASSOCIATION BETWEEN CSS

The previous section highlighted the most frequently employed CCS. This stage focuses on identifying the associations between the CCS and how often these are repeated across the lifecycles. Table 3 shows the degree of association between the CCS, which is a metric designed for the identification of the dominant associations between the various CCS. Degree of Association is defined as the metric that reflects the number of times that a CCS (source) is followed by target CCS (e.g. Strategy is followed by Analysis in three different lifecycles) in the examined lifecycles. It facilitates the observation of the connections between specific core cycle steps, through highlighting which CCS associations are most frequently used and recognize some of the strongest and weakest of them. As it is evident in Table 4 the strongest links are those between 'Implementation' to 'Monitor', 'Monitor' to 'Control' and 'Modeling' to 'Implementation' while there are also some other frequently used as 'Analysis' to 'Design', 'Control' to 'Refinement', 'Strategy' to 'Analysis', 'System configuration' to 'Enactment' and 'Planning' to 'Strategy'.

Table 3 Degree of Association (DoA > = 2)

No.	source CCS	target CCS	Degree of Association
1	Implementation	Monitor	5
2	Monitor	Control	5
3	Modeling	Implementation	4
4	Analysis	Design	3
5	Control	Refinement	3
6	Planning	Strategy	3
7	Strategy	Analysis	3
8	System Configuration	Enactment	3
9	Analysis	System Configuration	2
10	Design	Analysis	2
11	Design	Modeling	2
12	Design	System Configuration	2
13	Enactment	Evaluation	2
14	Refinement	Planning Review	2

Apart from the frequency of core cycle steps, the sequence in which they appear in the selected lifecycle models is also a valuable feature that could be further researched. This information might be useful to show that some core cycle steps are only used as initial, other after the initial and some last. Moreover, one can observe if there are some standard sequences between, usually two CCS that most authors used. For that reason, the authors intend to analyze these associations and create criteria which will include that type of standard sequences of CCS or CCS that are used at the same point in a life cycle model and have the same or similar definition. Those criteria will be presented in detail in the future in a new research paper.

CONCLUSIONS

This paper provided an approach regarding the notion of core cycle steps of a BPM lifecycle. After the selection and review of the most highly cited BPM lifecycles the authors identified some issues in the existing approaches. Those issues had mainly to do with the different orientation, application along with some naming problems of these approaches. We proposed a procedure in order to transform these BPM lifecycle steps into more comprehensive ones that we named them core cycle steps. The identification of the existing naming or placement into the lifecycle sequence was followed by the naming convention and normalization of the cycle steps based on some specific guidelines. That is how the names of the core cycle steps were produced. Furthermore to specify the exact placement of a core cycle step in a lifecycle model we calculated the frequency of occurrence of each step and the degree of association between two core cycle steps. In that way we proposed an overall solution to the issues that were identified. In the future all this

work will be expanded by creating a graph that shows the weight of each association. This will help in the production of a new, global and more systematic BPM lifecycle model that will consist of the present proposed core cycle steps.

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Open Source BPMS for the Public Sector: A case study

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Abstract

Despite the technological dominance in almost every aspect of the business world, it is a fact that many businesses lack of process automation, leading the employees to work inefficiently, wasting time in repetitive, sometimes even unnecessary procedures. In this context, there is a great loss in the business' revenue and the available resources are not properly distributed. This lack of automation is apparent in the Greek Public Sector, where the technological integration remains at a very low level. The purpose of this research is to point out the importance of Business Process Management and how Business Process Management Systems can be adapted in businesses in an attempt to improve its performance. More specifically, this paper describes how an open-source Business Process Management System can be used in a public organization, such as the Technical University of Crete, in order to automate a time consuming process. In the present case study, the process of printer cartridges procurement is chosen as an instance of a less automated and quite time consuming process, since it includes repetitive tasks that are currently being handled manually by the Department of Administrative Computer Infrastructure. Our case study includes the still challenging task of modeling a process with feedback (loop), an issue not covered in previous work. In order to find out whether this kind of systems can indeed improve the performance of the institution, a pilot test was conducted, followed by a survey, with the purpose to examine whether such systems would be welcomed by the stakeholders. The results of the latter proved to be encouraging and denote the need of these systems, both from users' and administrators' side.

KEYWORDS

Business Process Management Systems, Workflow Management Systems, Open Source Software, Case Study

INTRODUCTION

Any attempt for Business improvement would be inconsequential, in the absence of deep understanding of each and every work procedure combined with the comprehension of resources' allocation. In large organizations, the complexity of the procedures creates an ambiguous environment, making this knowledge even more difficult to be attained. The aforementioned complexity urged the emergence of Business Process Management (BPM), since with BPM business processes are enhanced by utilizing methods and software in order to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents etc. (van der Aalst et al., 2003). Via BPM, work is divided into processes where work activities are separated into well-defined tasks (Georgakopoulos et al., 1995).

One of the greatest challenges in Greek public organizations is the failure to provide clear and accurate task assignments and process mapping, which leads to responsibility disclaiming and limits transparency. In addition to that, the omnipresence of bureaucracy and the obsolete legal framework (Papadopoulos et al., 2018) impels the personnel to work with minimal agility. Past experience (Ko, 2009) has shown that the lack of established procedures within an organization can lead to great losses, since individuals may take initiatives that do not comply with the organizations' strategy and violate regulations without being noticed. In such cases having established processes isn't enough. Although Business Process Management does not necessarily require the use of any technological means, Business Process Management Systems (BPMS) can be used to execute the business processes and monitor their performance and activities. Furthermore, BPMSs offer various reports and analytics that can be used further as an aid to the decision making and operational research endeavours (Chalikias et al. 2003).

The purpose of this case study is to benefit from the implementation of BPM in an attempt to increase the productivity and limit the expenses of an organization. To achieve that, a BPMS was used to automate the process of ink cartridges' procurement, which according to the Department of Computer Infrastructure Administration of the Technical University of Crete, is a time consuming process that distracts the administrators from other more important tasks.

This paper firstly reviews the open source BPMS frameworks (Section 2). In Section 3 we present our case study, the process and our results and recommendations. We conclude in Section 4.

OPEN SOURCE BPMS

According to the reference model of the Workflow Management Coalition (WfMC) (Hollingsworth, 1995; van der Aalst, 2013) every Workflow Management System –and, as an extension, every BPM System– consists of the following components:

- *Process definition tools*, usually a graphical environment where the process model is designed by using a Business Process Modelling Language.
- *Workflow enactment service*, which is essentially the run-time environment that utilizes one or more *workflow engines*, that define how the system will operate based on the process model.
- *Administration and monitoring tools*, like dashboards with live data from the process progress or different types of reports with usage statistics.

Recent works propose two more components (Burattin, 2015):

- *Integration Tools*, that allow the collaboration of the BPMS with other existing business software.
- *Repositories*, where data, documents, process models etc. are stored.

Before choosing the BPMS that was employed for the development of our platform, six different open source BPMSs were tested. For this purpose a simple process was executed with each of the following systems: [ProcessMaker 3.2.1](#), [Camunda BPM 7.8.0](#), [Bonita BPM 7.6.3](#), [Activiti 7.0](#), [jBPM 6.4](#) and [YAWL 4.2](#) in order to conduct a comparative analysis.

The comparison of these systems was based on:

- a) the ease of installation and configuration
- b) the ease of development and execution of a process based on standards
- c) the friendly and modern interface

It should be mentioned that for the present case study, the systems were used as standalones and they were not embedded in other existing platforms used by the organization. After performing the necessary process on Camunda BPM, Bonita BPM, Activiti and jBPM, the systems were deemed to be less appropriate for the case in question, since they are Java-based applications that demand further configuration and cannot offer the desired interface when used as standalones. On the contrary, even though YAWL was evaluated as the easiest software to handle, it was not selected, as it did not follow BPMN as a modelling standard and the provided interface seemed outdated. Thus, ProcessMaker was selected as the most appropriate system since it follows BPMN and it is provided in a software bundle easy to install and execute. Essentially, ProcessMaker is the only LAMP/WAMP stack (Linux/Windows, Apache Server, MySQL Database, PHP programming language), the deployment of which is easier compared to the mentioned Java-based stacks.

CASE STUDY

Introducing Business Process Management into a Greek public organization is not an easy task. As it is suggested by Athanasopoulos et al. (2017) and Delias (2017), the whole project becomes more complicated due to restrictions posed by the legal framework and internal regulations of each organization. In addition to that, there is not a generic method that dictates the way that BPM and BPMSs can be integrated into businesses, and therefore every case should be considered as unique (Trkman, 2010).

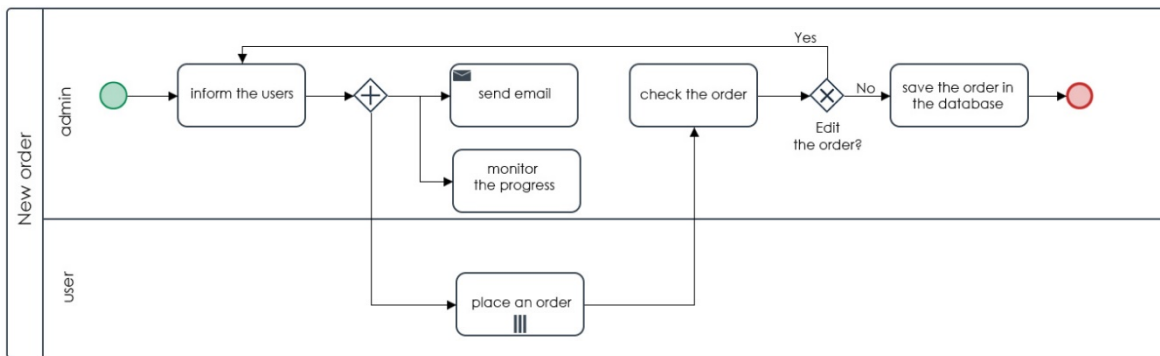
The first step for the present case study, was to identify the process that needed automation. After a meeting with the relevant parties in the Department of Administrative Computer Infrastructure, it was pointed out that although many processes can be automated, it is not suggested to proceed to a complete automation, since there are restrictions regarding the internal regulations. Moreover, it was highlighted that a simple and quite time consuming process that can be easily automated, is the procurement of ink cartridges for the University. The current procedure includes phone calls and emails combined with continuous communication between the administrators and the users. Given that most of the users cannot properly specify the desired ink cartridge, the majority of the time is consumed to resolve misunderstandings. Additionally, in numerous cases, ink cartridges that will never be used are purchased.

Taking all the above into consideration, the purpose of this case study is to use a Business Processes Management System in order to automate the process of procurement, aspiring to reduce the time spent on the engagement with the users, while limiting possible mistakes, and keeping track of the consumption, and, therefore, the expenses. In order to accomplish that, a new platform was developed, using the selected open source BPMS, where the users can log in and place their orders, while the administrators can handle every task related to the procurement. On top of that, to further facilitate the administrator, the system automatically provides an aggregate list of the selected products, limiting the time spent in double checks and the collection of the orders. Lastly, “history tools” are offered, where the administrators can view past orders, and statistics of usage, in pursuance of a better tracking of the expenses.

Modeling the Process

In Figure 1 the main process that was deployed is depicted using version 2.0 of the Business Process Management Notation (BPMN) language. BPMN is a process modeling language that allows the graphical representation of workflow, roles, limitations etc. It was developed due to the need for a human-readable way of process representation that would be both understood by business and IT people (Scheithauer and Wirtz, 2008). As shown, there are two roles regarding the stakeholders, i.e. the user and the administrator.

Figure 1. Main process model in terms of BPMN 2.0



The process begins with the *inform the users* task, where the administrator selects which users will take part in the procurement process. When this task is completed, three tasks are simultaneously initiated:

- The *send mail* task, which is an automated task where an email is sent to the users, informing them for the launch of the procurement process and providing them with instructions.
- The *place an order* task, which is the only task directly assigned to the users, prompting them to fill a form with their order. The form is designed to be user-friendly, and the information is presented in such a way as to limit possible mistakes, e.g. there is a list with printers linked to their corresponding products, thus preventing a user from mismatching a product (an ink cartridge) to a printer.
- The *monitor the progress* task, where the administrator can check who has already placed an order.

As someone may notice in Figure 1, the above tasks follow a parallel gateway but the flow does not converge after they finish. This modeling approach is contrary to BPMN good practice, however, it is the best approach for the ProcessMaker tool, where the send email task is terminated automatically and the monitor the progress task is terminated by the user, and therefore they do not need to be connected to an end event. Thus, we report that ProcessMaker does not support well the convergence to an AND gateway.

When the task *place an order* is completed by all the users (or when the procurement period is over), the task *check the order* is assigned to the administrator, who has to go through every order and accept it or decline it. If one or more orders are not accepted, the process starts from the ground up, solely with the users who need to place their order again. In the event that no mistakes are found in the placed orders, the process can move on and an aggregated list of the ordered products will be automatically exported for the administrator's assistance (*save the order in the database* task), leading the process to end.

At this point, there should be a special reference regarding the tasks with feedback (loop). The selected BPMS, as well as other BPMSs, have an issue on handling parallel tasks (e.g. *place an order*). In many cases a task has to be claimed by many users separately, and for this reason the flow doesn't move on until every single user claims his task. In cases like procurements there is a great likelihood that users will fail to complete their assigned task, resulting the process to stall, leading the developers to seek for workarounds. In our case, a new task was created and assigned to the administrator, the execution of which results the proper editing of some database's values, forcing the system to end the parallel task whenever the administrator wishes to do so. For further information and technical details on this topic, please consult the thesis of Benioudaki (2019).

Results and Recommendations

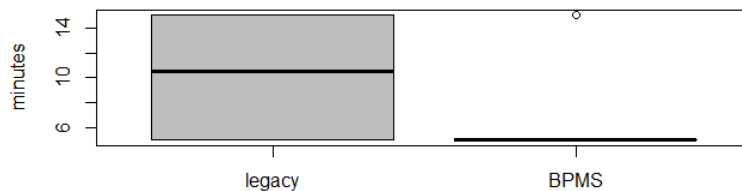
To ensure that the developed system would meet the expectations of a real-world project, a pilot test was conducted among the members of the Technical University of Crete. For the purpose of the case study, the person in charge for the particular procurements was given the role of the administrator. For this reason, two meetings were required in order to demonstrate the platform and train the stakeholders for the role of the administrator, since during the test,

assistance from the developers would not be provided, in an attempt to observe the users' adaptation to the new platform. In addition, 19 members of the university's community were given the role of the user, without any further training, only relying on the directions given in an informative email. The users were given a period of ten days to place their order and during this period every case scenario was tested e.g. what happens if a user needs to place an order after the end of the given period, if he needs to edit his order after the submission, or if he does not place his order at all.

Subsequently, a user satisfaction survey was conducted, where the 19 individuals that had been given the role of the user participated. The sample of the users consists of 57.89% females and 42.11% males, where the majority (42.11%) was above 45 years old, while 31.57% were among 18-25 and 26.32% were between 36-45 years old. In terms of the participants' profession, the largest share (36.84%) affirmed to be Laboratory Teaching Staff Members, 31.58% were students, 21.05% were administrative staff and, lastly, 10.53% were professors.

The first crucial factor to determine the success of the project refers to the time needed for an order to be placed, with and without the developed platform. For both cases, possible responses were 1) less than 5 minutes (m), 2) 6-10m, 3) 11-15m, 4) more than 15m. Figure 2 shows the boxplot comparing process time with the existing approach (legacy) compared to the use of the BPMS. To compute the boxplot, we used specific values for the four alternatives: (1) 5m, (2) 8m, (3) 13m and (4) 15m. So this is a conservative figure that, however, shows a substantial acceleration of the process, halving execution time.

Figure 2. Acceleration of the process in minutes

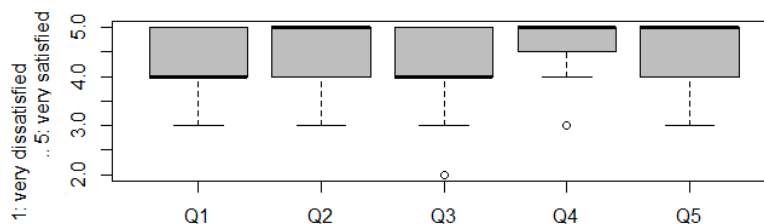


Another key question for establishing the success of the platform, was whether the participants thought that the platform improved or not the procedure. The vast majority (94.74%) stated that the platform improved the procurement process, while 5.26% (one user) stated that the platform neither improved nor worsened the process.

In Figure 3 the satisfaction of the participants is illustrated for the following questions:

- Q1: Rate the user friendliness of the platform e.g. menu, the messages etc.
- Q2: How satisfied are you regarding the ease of navigation within the platform?
- Q3: Rate the graphics of the platform e.g. colors, buttons, icons etc.
- Q4: Rate the overall ease of filling an order form (lists with available products, input fields etc).
- Q5: Rate the overall experience in using the developed platform for an order placement.

Figure 3. Results of satisfaction survey



For the above mentioned questions the users had to express their satisfaction in a scale from one to five, where, five (5) corresponds to the user being *very satisfied*, four (4) to *satisfied*, three (3) to *neutral*, two (2) to *dissatisfied*, and, one (1) to *very dissatisfied*.

As the purpose of the project was to examine whether such systems can be easily integrated within public institutions, the developed platform, as an instance of the simplest way of integrating a BPMS in an organization, proved to be adequate for the automation of the ink cartridges' procurement process, leaving space for further improvement. Also, as far as the administrators are concerned, not only were they willing to adopt the developed system, but they found the system easy to use. Furthermore, during the development and the following pilot test, certain issues arose regarding the security of the platform. From our experience, when developing such solutions, emphasis should be given to the security as well as to the development of the process.

CONCLUSIONS

Even though there are some attempts for technological integration in the Greek Public Sector, an adequate level of automation seems to be far from occurring. Our case study recommends the use of an open-source Business Process Management System that contributed to the automation of the time consuming process of ink cartridges' procurement. The feedback gained from the pilot test and the satisfaction survey is encouraging.

Our work extends previous works (Athanasopoulos et al., 2017) by using an open source solution and by comparing the available frameworks. Also, the present paper refers to the parallel tasks, which to the authors' best knowledge is a feature that needs special handling in numerous BPMSs and is an issue that needs further documentation.

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Session 4: Mathematical Programming

chair: Pavlos Delias

Truck Loading for Fuel Distribution with Axle Weight Restrictions

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Abstract

The work presented in this paper aims to address a novel tank truck loading problem that incorporates explicitly safety restrictions applicable during loading and unloading of Hazardous (liquid) cargo on tank trucks. The loading restrictions under consideration aim to enhance vehicle's stability and to avoid overturns, which in most of the cases are attributed to the unbalanced cargo loaded on the vehicles. In order to ensure stability and respectively to avoid incidents caused by overturned vehicles, truck manufacturers and each country's transportation authorities provide restrictions concerning the maximum weights limits of each truck (i.e. max. gross weight, max. weight distributed over each axle). The innovation of our model comes from the explicit incorporation of the axle weight restrictions throughout all stages of a multi-stop distribution route of a tank truck with more than two (groups of) axles. The formulation of the axle weight distribution constraints are based on the development of closed-form formulas (derived from structural analysis) for estimating the weights distributed over each axle of the tank truck. The results indicate that the axle weight constraints have a small performance impact in terms of loading a tank truck.

KEYWORDS

Truck Loading; axle weight constraints; hazardous materials; three moments equation

INTRODUCTION

A major proactive safety measure to avoid accidents caused by overturned vehicles relates to the balanced loading of the cargo over the length of the body of the vehicle. In order to ensure stability and respectively to avoid incidents caused by overturned vehicles, truck manufacturers provide restrictions concerning each truck's maximum weights (max gross and max weight distributed per axle). Moreover, similar restrictions are imposed by each country's transport authorities. Exceeding these limits can cause lack of en-route stability, possible reduction of the braking system effectiveness, loss of maneuverability and also danger of tire overheat (Jacob and Beaumelle, 2010).

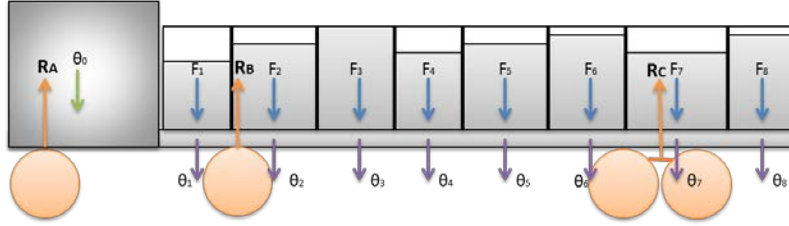
The work presented in this paper provides a loading model for fuel distribution that incorporates axle weight restrictions on multi-compartment heavy rigid tank trucks. Previous related work on the use of relevant constraints in loading trucks for freight distribution in general was focused on estimating and controlling the weights distributed over two groups of axles (front and rear group) by applying the static equilibrium conditions (Pollaris et al., 2014; Alonso et al., 2016; Ramos et al., 2018). The objective of the analysis that follows is to provide a computational model for estimating the reaction forces coming from more than two groups of vehicle axles. The concentrated weight force acting on each vehicle axle is expressed as a function of the geometrical characteristics of the tank truck, the compartments configurations, and the fuel quantities assigned in its compartments. The proposed axle weight constraints impose that the weight forces acting on the vehicle axles do not exceed predefined limits. The emerging constraints are taken into account for loading a tank truck that has to deliver a sequence of multiple-fuel orders in a single route. The emerging loading problem aims to assign all ordered quantities to the truck's compartments so that the axle weight constraints are respected throughout the entire delivery route (i.e. the weight distributed over each axle of a truck must be at all phases of the delivery route below or equal to their maximum limits). We provide a MILP (Mixed Integer Linear Programming) formulation of the emerging loading problem and assess the impact of the axle weight constraints on the utilization of tank truck capacity.

WEIGHT DISTRIBUTION FOR A THREE AXLES TANK -TRUCK

Our analysis provides the computation of the weights distributed over the axles of the truck which is based on the static equilibrium conditions and the three moments equation (Wheeler, 1876). The latter expresses the equilibrium

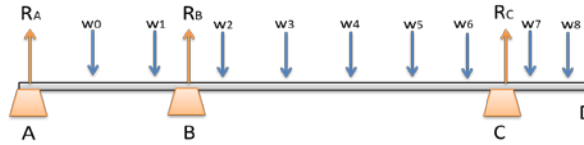
conditions for the bending moments (internal rotational effect which can cause a section to bend). The forces acting on the axles of the truck are created by the weight of the fuel quantities in the truck compartments and the weight of the various parts of the body of the truck. We divide the body of the truck into sections as indicated in Figure 1. In more detail, Figure 1 presents: i) the reaction forces (R_A , R_B and R_C) coming from the three axles (axle or group of axles exist in three different locations across the truck) of the truck, ii) the concentrated weight forces coming from the centroid of the truck's sections (θ_0 to θ_8), iii) the concentrated weight forces coming from the centroids of the loads placed in the compartments (F_1 to F_8). It should be noted that the reaction force R_C is a unique force coming from the middle of the rear tandem axle.

Figure 1: Example of a three axles tank truck configuration.



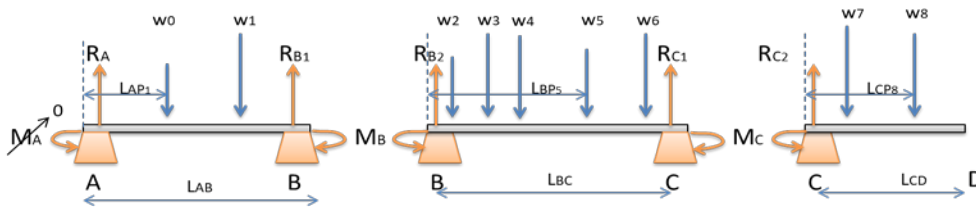
We model the three-axle tank truck with a three-support beam as illustrated in Fig. 2. The weight forces (F_j and θ_j for $j = 0, \dots, N$) acting on the beam are assumed as point loads acting at points P_j (middle points of the corresponding sections) and for simplicity reasons their summation is illustrated as w_j . The resulting model however falls to the category of statically indeterminate structures where the static equilibrium conditions (all x-axis forces, all y-axis forces, and all moments sum up to zero) are not sufficient to calculate the reaction forces at the supports of the beam. This situation is resolved by using the Three Moments equation which expresses the equilibrium conditions for the bending moments at the support points of the beam, i.e., A, B, C.

Figure 2. Concentrated weight forces applied across a uniform beam with three supports.



In order to apply the three-moments equation the body of the truck is partitioned into three sections by considering one cut at each of the support points (axles). In figure 3 we present this partition of the tank truck into sections AB, BC & CD. The forces w_j acting on the beam are grouped to three sets depending on the section on which point P_j belongs to. Hence, we have the following sets of forces: w_j for: $j \in S_{AB}$ i.e., $P_j \in AB$, $j \in S_{BC}$ i.e., $P_j \in BC$, and $j \in S_{CD}$ i.e., $P_j \in CD$. Moreover, we denote $|S_{AB}|$, $|S_{BC}|$, $|S_{CD}|$ by n_{AB} , n_{BC} , n_{CD} respectively. The distance between two points (i, P_j) marked on the beam is denoted by L_{iP_j} .

Figure 3: Simplified truck structure split into three sections.



Formula (1) presents the Three Moment equation customized for the three-support structure under considerations. Moreover, no bending moment exist at the two ends of the truck (i.e. $M_A = M_D = 0$).

$$M_A * L_{AB} + 2M_B(L_{AB} + L_{BC}) + M_C * L_{BC} = - \sum_{j \in S_{AB}} \frac{L_{AP_j}(L_{AB}^2 - L_{AP_j}^2)}{L_{AB}} w_j - \sum_{j \in S_{BC}} \frac{L_{CP_j}(L_{BC}^2 - L_{CP_j}^2)}{L_{BC}} w_j \quad (1)$$

Taking into consideration the static equilibrium conditions for each section (AB, BC and CD) for both moments and forces and that $R_B = R_{B1} + R_{B2}$, the values of the reactions forces R_A , R_B and R_C can be calculated as indicated below (equations (3)-(5)).

$$M_B = - \sum_{j=0}^N \mu_j * w_j \quad (2)$$

$$R_A = \sum_{j=0}^N \lambda_j^A * w_j \quad (3)$$

$$\mathbf{R}_B = \sum_{j=0}^N \lambda_j^B * \mathbf{w}_j \quad (4)$$

$$\mathbf{R}_C = \sum_{j=0}^N \lambda_j^C * \mathbf{w}_j \quad (5)$$

Where:

$$\begin{aligned} \text{For } j \in S_{AB} : \mu_j &= \frac{L_{AP_j}(L_{AB}^2 - L_{AP_j}^2)}{2 * L_{AC} * L_{AB}}, \lambda_j^A = \frac{L_{AB} - L_{AP_j} - \mu_j}{L_{AB}}, \lambda_j^B = \frac{L_{BC} * L_{AP_j} + L_{AC} * \mu_j}{L_{AB} * L_{BC}}, \lambda_j^C = -\frac{\mu_j}{L_{BC}} \\ \text{For } j \in S_{BC} : \mu_j &= \frac{L_{CP_j}(L_{BC}^2 - L_{CP_j}^2)}{2 * L_{AC} * L_{BC}}, \lambda_j^A = \frac{-\mu_j}{L_{AB}}, \lambda_j^B = \frac{L_{AC} * \mu_j + L_{AB} * L_{BC} - L_{BP_j} * L_{AB}}{L_{AB} * L_{BC}}, \lambda_j^C = \frac{L_{BP_j} - \mu_j}{L_{BC}} \\ \text{For } j \in S_{CD} : \mu_j &= \frac{L_{CP_j} * L_{BC}}{2 * L_{AC}}, \lambda_j^A = \frac{-\mu_j}{L_{AB}}, \lambda_j^B = \frac{L_{AC} * \mu_j - L_{AB} * L_{CP_j}}{L_{AB} * L_{BC}}, \lambda_j^C = \frac{L_{BC} + L_{CP_j} - \mu_j}{L_{BC}} \end{aligned}$$

It is worth noting that each reaction force can be expressed as a weighted sum of the weight forces acting on the body of the truck. This finding facilitates the incorporation of the maximum axle weight restrictions in the loading model as linear constraints.

Model Formulation

We assume a vehicle v with a three axles structure for servicing the order items Π_i of the route \mathcal{R} . The set of links between the customers of route \mathcal{R} are presented by $A_{\mathcal{R}} = \{(i_0, i_1), \dots, (i_{n_{\mathcal{R}}-1}, i_{n_{\mathcal{R}}}), (i_{n_{\mathcal{R}}}, i_{n+1})\}$, where i_0 and i_{n+1} denote the depot. We assume the following restrictions on the axle weight distribution: i) the first two axles of the truck can bear a max total weight of W_F , whereas the third axle can bear a max total weight of W_R . The model is formulated as a MIP problem. The objective of the proposed loading problem is to determine a feasible assignment of the orders to compartments that minimizes: i) the total deviation between the ordered and delivered fuel quantities, and ii) the unused space of the compartments assigned a positive load. It is worth noting that each compartment can be assigned up to one order item. To formulate the problem, we use the notation as presented in table 1 and the decision variables as presented in table 2.

Table 1: Notation used in the loading model.

c : index for compartment	$p_r, r \in P$: Fuel involved in order item r
K_v : Set of compartments of vehicle v	h : Axle or group of axles (e.g. tandem or triple axles), $h \in H$
H : Set of axles ($\{A, B, C\}$)	$A_{\mathcal{R}}$: Set of links between customers of route \mathcal{R}
\mathcal{R} : Set of orders	$B > 0$: Maximum net weight of vehicle v
i : Order of customer, $i \in \mathcal{R}$	$Q_c > 0, c \in K_v$: Maximum volume capacity of compartment c
Π_i : Set of order items of order i	$W_F > 0$: Maximum permitted weight of load over the front axles
r : Item of order i , $r \in \Pi_i$	$W_R > 0$: Maximum permitted weight of load over the rear axles
Π : Set of all order items	$\beta_r \in [0, 1], r \in \Pi$: Acceptable quantity flexibility of item r
P : Set of all fuel types	$\pi_r, r \in \Pi$: Total requested volume quantity of item r
i_0 : Origin	$\rho_{p_r}, p_r \in P$: Specific weight of the fuel involved in order item r
i_{n+1} : Destination	

Table 2: Decision variables used in the loading model.

$z_{rc} \in \{0, 1\}, r \in \Pi, c \in K_v$, which take value 1 if item r is assigned to compartment c
$q_{rc} \geq 0, r \in \Pi, c \in K_v$, which express the volume quantity of item r assigned to compartment c
$w_{ijc} \geq 0, (i, j) \in A_{\Pi}, c \in K_v$, which expresses the weight of the fuel quantity loaded in compartment c that travels through arc (i, j) of route \mathcal{R} and of the weight of the truck's section related to the same compartment
$R_h, h \in H_v$, variable expressing the reaction forces coming from axle h
$e \geq 0$ which express the total unused space of those compartments that are assigned a positive load (the space of the compartments left empty is not included)
$u_r, r \in \Pi$ which express the deviation between the initial order item quantity, and the relevant quantity for that item loaded to the vehicle
$\varphi_{c1}, \varphi_{c2} \in \{0, 1\}, c \in K_v$ auxiliary variables which are used for modeling reasons

$$\text{Minlex} (\sum_{r \in \Pi} u_r, e) \quad (6)$$

Subject to:

$$\sum_{r \in \Pi} z_{rc} \leq 1, \quad \forall c \in K_v \quad (7)$$

$$\sum_{r \in \Pi} q_{rc} \leq \sum_{r \in \Pi} Q_c z_{rc}, \quad \forall c \in K_v \quad (8)$$

$$\sum_{c \in K} q_{rc} - \pi_r \leq u_r, \quad r \in \Pi \quad (9)$$

$$\pi_r - \sum_{c \in K_v} q_{rc} \leq u_r, \quad r \in \Pi \quad (10)$$

$$u_r \leq \beta_r \pi_r, \quad r \in \Pi \quad (11)$$

$$\sum_{r \in \Pi} \sum_{c \in K_v} q_{rc} \rho_r \leq B \quad (12)$$

$$w_{i_0 i_1 c} = \sum_{r \in \Pi} q_{cr} \rho_r, \quad c \in K_v \quad (13)$$

$$w_{i_n i_{n+1} c} = 0, \quad c \in K_v \quad (14)$$

$$w_{i_{k-1} i_k c} - w_{i_k i_{k+1} c} = \sum_{r \in \Pi} q_{cr} \rho_r, \quad i_k \in \Pi, c \in K_v \quad (15)$$

$$\sum_{r \in \Pi} \sum_{c \in K_v} (z_{rc} * Q_c - q_{rc}) = e \quad (16)$$

$$\sum_{r \in \Pi} q_{rc} \geq 0.8 * Q_c * \varphi_{c1} \quad \forall c \in K_v \quad (17)$$

$$\sum_{r \in \Pi} q_{rc} + (\varphi_{c2} - 1) Q_c \leq 0.2 * Q_c \quad \forall c \in K_v \quad (18)$$

$$\varphi_{c1} + \varphi_{c2} = 1 \quad \forall c \in K_v \quad (19)$$

$$R_A + R_B \leq W_F \quad \forall (i, j) \in A_{\mathcal{R}} \quad (20)$$

$$R_C \leq W_R \quad \forall (i, j) \in A_{\mathcal{R}} \quad (21)$$

Constraint (7) denotes that up to one order item can be assigned to each compartment. Constraint (8) indicates that the volume quantity of the order item assigned to a compartment cannot exceed its capacity. Constraints (9) and (10) determine the deviation between the ordered and delivered quantity of a customer's order item (variable u_r). In addition, constraint (11) indicates that an order item can only change from its initial quantity by $\pm(\beta_r \cdot 100)\%$. Constraint (12) denotes that the total quantity of the order items assigned to a vehicle, cannot exceed its maximum permitted net weight. Constraint (13) states that at the beginning of a route the weight of the load placed in a compartment, is equal with the quantity of the order item assigned to the specific compartment, while constraint (14) indicates that no load should exist in the vehicle's compartments when it reaches its final destination (depot). Constraint (15) states that after a customer is visited, the order items of his order get unloaded from the vehicle. Constraint (16) determine the total unused space coming from the compartments assigned with an order item. Constraint (17), (18) and (19) state that every compartment has to be filled either less than the 20% or above the 80% of their total capacity. Constraint (20) and (21) imply that the total weight that can be distributed over the front and respectively the rear axles should not exceed its maximum permitted weight limits. Using the analysis for the calculation of the reaction forces coming from the axles of the tank truck, presented in section 2, equation (20) can be replaced by equation (22) and equation (21) by equation (23).

$$\sum_{c=0}^N \lambda_c^A * w_{ijc} + \sum_{c=0}^N \lambda_c^B * w_{ijc} \leq W_F \quad \forall (i, j) \in A_{\Pi} \quad (22)$$

$$\sum_{c=0}^N \lambda_c^C * w_{ijc} \leq W_R \quad \forall (i, j) \in A_{\Pi} \quad (23)$$

COMPUTATIONAL EXPERIMENTS AND RESULTS

In table 3 we presented the results of the experiments performed for a truck with a three-axle structure of the loading process with and without axle weight constraints, performed for 100 problem sets. From the results presented in the table 3 we observe that we achieved almost similar results for both loading processes and in more detail that:

- i. Out of the 493 orders (for both loading processes) there have been 477 orders routed and 16 orders left unassigned.
- ii. The loading process with axle weight constraints, has left unassigned the 7,48% and similarly the loading process without axle weight constraints has left unassigned the 7,51% of the order volume.
- iii. The loading process with axle weight constraints led to a 0,32% of quantity reduction and to a 7,97% of quantity increase. The loading process without axle weight constraints, led to similar results which are 0,2% and 8,22% respectively.
- iv. There is a minor difference of 0,3% in the ALF between the two loading processes (i.e. 84,34% for the loading process with and 84,68% for the loading process without axle weight constraints).

Table 3: Results of the loading model with and without axle weight restrictions for the 4-axes truck.

Axle Constraints	Total number of orders	Routed Orders	Unrouted Orders	% Unassigned vol. of orders	% Quantity-Reduction	% Quantity-Increase	Average Loading Factor (ALF)
With	493	477	16	7,48%	0,32%	7,97%	84,38%
Without	493	477	16	7,51%	0,20%	8,22%	84,68%

CONCLUSIONS

In this work we have presented a fuel loading and distribution model that incorporates, dynamic axle weight constraints. The need of using axle weight constraints emerges from: i) the existence of legislation imposing maximum axle weight limits during road transportation of cargo and ii) the need to enhance road safety and to avoid incidents caused by overturned vehicles. The model is based in multi-compartments rigid tank trucks with axles or group of axles located at three points across the truck. The innovation of our model comes from the incorporation of advanced structural analysis theory for the calculation of the weight distribution (i.e. cargo and truck's weight) over each one of the truck's axles. The calculations of the axle weight distribution include the geometrical characteristics of the truck and are performed at each step (before every customer visit) of the truck's delivery route. The results of the experiments lead to the conclusions that the axle weight restrictions result to a modest deterioration of the performance of the loading model (i.e. capacity utilization, number of served customers, delivered quantity). Resulting that axle weight constraints can easily be incorporated in real life loading problems, only with a small performance impact.

ACKNOWLEDGEMENT

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MILP model for production scheduling and lot sizing

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Abstract

Optimization of production process represents a critical component for competitive success. In this paper we focus on production of micronutrients for animal consumption. A Mixed Integer Linear Programming Model (MILP) is proposed for simultaneous optimization of production planning and scheduling a set of parallel production units. Continuous production process is characterized by a number of products sorted in different product families. The model explicitly considers changeover cost and changeover time through a matrix of compatibility between product families as well as capacity limitations of different production units. For a given set of orders composed from quantity of products with respective deadlines the aim is generate an optimal production plan taking into account the production, changeover and capacity utilization costs. Inventories and backorders are not permitted. The model is applied to a case study that considers optimal lot size and schedule of five parallel machines over a 7 days planning horizon in order to meet the weekly demand for six products that belong to five product families. Obtained results prove the superiority of proposed approach in comparison with the current practice.

Keywords: premix production, lot sizing, scheduling, mixed integer linear programming

INTRODUCTION

Production planning and scheduling represents one of the most important activities in supply chain management. Planning and scheduling activities consider allocation of scarce resources between competing activities in order to meet efficiency criteria (Kopanos and Puigjaner, 2019). In this paper, we consider a production process with a set of continuous parallel units. More precisely, we developed a mathematical approach for simultaneous production planning and scheduling of continuous parallel units producing a number of different products that can be classified in a set of production families. The model considers compatibility between families, changeovers, limited capacity of production units and delivery deadlines. the objective of the problem is to meet item demands without backlogging at minimal total cost. Given the importance of this class of problems a number of similar approaches for integrated production planning and scheduling have been proposed in literature, though no methods have been reported for specific problem analyzed here. The papers served as the main references for model proposed here are briefly described. Kopanos et al. (2010) proposed a lot sizing and production scheduling problem in a multiproduct yoghurt production line of a real-life dairy plant. Authors developed a MILP model based on a definition of families of products, timing and capacity constraints. Doganis and Sarimveis (2008) developed a customized MILP model for optimizing yogurt packaging lines that consist of multiple parallel machines. Ronconi and Birgin (2012) examine the flowshop scheduling problem with no storage constraints and with blocking in process involving both earliness and tardiness costs. The authors compared a set of alternative mixed integer models ferom the aspect of computational efficiency. For an in-depth review of integrated lot sizing and scheduling problems the interested reader is referred to the papers of Capil et al. (2015). The remainder of this paper is organized as follows. The problem is described in Section 2. MILP model for simultaneous lot sizing and production scheduling of premixes production is given in Section 3. Numerical experiment, inputs and associated results based on a real set of production orders are presented in Section 4. Section 5 contains concluding remarks and future research directions.

PROBLEM STATEMENT

In this paper, we address the lot-sizing and scheduling problem in production of premix of micronutrients that are used in the feed production for animal consumption. The production process consists from the mixing of specific raw materials that each formula has, respecting the exact amounts of all of them. The process starts when a customer places an order. Each order may have different products or references in different amounts. Due to the highly specified formulas and that the entire supply chain is designed as a make-to-order model there is no a long-term stock of finished products. The main production stages are as follows: (1) Production order release. The process of production orders release is done by the programmer for entire shift without a detailed processing schedule. The programmer checks the availability of raw materials included in a specific reference. If there are enough inventories, he programs the SKUs (Stock Keeping Units) based on the delivery time related to the order, prioritizing the orders with a closer deadline. The shift supervisor chooses the specific sequence of the orders and assigns them to the machines based on the minimum and maximum capacity of mixer machines, compatibility between raw materials and formula specification. (2) Loading of mixing machines. The loading is made in 1 of M mixing machines of different capacity. (3) The mixing process. The mixer starts the mixing process and after a fixed processing time the product is packaged ((4) Bagging) and sent to the warehouse of finished products ((5) Temporary storage) for later delivery.

MILP MODEL

Based on the problem statement it can be concluded that the order assignment to a set of machines depends on the supervisor judgment and his ability to organize the production. This is the main reason why there is a need for a tool that will take the production orders as inputs, assign them to a set of machines taking into account the cost of production, the delivery dates and times, capacities of the machines and compatibility between product families. The aforementioned problem was formulated as a Mixed Integer Linear Programming (MILP) model. Before describing the model in detail, it is needed to define the problem parameters and decision variables.

Sets:

- T set of time periods, $t = 1 \dots T$;
- M set of machines, $m = 1, \dots, M$;
- F set of product families, $f = 1, \dots, F$;
- F_1 Set of pairs (k, l) , where k, l is a pair of incompatible families, $k, l \in F$
- P set of products, $p = 1, \dots, P$;
- O set of orders, $o = 1, \dots, O$;

Parameters:

- d_{op} demand for product p in the order o , $o = 1, \dots, O$, $p = 1, \dots, P$;
- α_o due date of order o ;
- c_{fpm}^s setup cost of machine m for production of product p that belongs to family f ;
- c_m^{ch} changeover cost that includes regular cleaning that has to be done after each production cycle
- c_{fpm}^o operational cost of machine m for production of product p that belongs to family f ;
- $c_{f_1m}^{ch}$ changeover cost between family f and family f_1 , $f, f_1 \in F, f \neq f_1$;
- ρ_m^{\min} minimum daily production rate of machine m ;
- ρ_m^{\max} maximum daily production rate of machine m ;
- η_m^{\min} maximum loading capacity of machine m ;
- η_m^{\max} minimum loading capacity of machine m ;
- c_m^{ut} utilization cost of machine m ;
- b_p^o preferred bag size of quantity of product p that belongs to order o ;

Decision variables:

- Π_{ofpm}^t quantity of order o sorted into bags of preferable size of product p that belongs to a family f assigned to machine m in period t ;
- P_{ofpm}^t quantity of product p that belongs to a family f for an order o assigned to machine m in period t , $P_{ofpm}^t = \Pi_{ofpm}^t \cdot b_p^o$;
- X_{klm}^{t+1} binary variable which represents changeover between product families k and l ($k, l \in F, k \neq l$) on machine m in periods t and $t+1$;
- Φ_{fm}^t binary variable which identifies if family f is assigned to machine m in period t ;
- Υ_{fpm}^t binary variable which identifies if product p which belongs to family f is assigned to machine m in period t ;

The MILP problem for the lot-sizing and scheduling problem in production of premix of micronutrients is formulated as follows:

$$\text{Minimize } Z = \sum_{o=1}^O \sum_{f=1}^F \sum_{p=1}^P \sum_{m=1}^M \sum_{t=1}^T ((c_{fpm}^s + c_m^{ch}) \cdot \Upsilon_{fpm}^t + c_{fpm}^o \cdot P_{ofpm}^t) + \sum_{f=1}^F \sum_{m=1}^M \sum_{t=1}^{T-1} c_{klm}^{ch} X_{klm}^{t+1} + \sum_{m=1}^M \sum_{t=1}^T \left(\eta_m^{\max} - \sum_{o=1}^O \sum_{f=1}^F \sum_{p=1}^P P_{ofpm}^t \right) \cdot c_m^{ut} + \sum_{o=1}^O \sum_{f=1}^F \sum_{p=1}^P \sum_{m=1}^M \sum_{t=1}^T (\alpha_o - t) P_{ofpm}^t + \sum_{o=1}^O \sum_{f=1}^F \sum_{p=1}^P \sum_{m=1}^M \sum_{t=1}^T c_m^{ut} \cdot \Upsilon_{fpm}^t \quad (1)$$

$$\sum_{o=1}^O \sum_{m=1}^M \sum_{t=1}^T P_{ofpm}^t = \sum_{o=1}^O d_{op}, \quad f = 1, \dots, F, \quad p = 1, \dots, P \quad (2)$$

$$\sum_{m=1}^M \sum_{t=1}^T P_{ofpm}^t = d_{op}, \quad o = 1, \dots, O, \quad f = 1, \dots, F, \quad p = 1, \dots, P \quad (3)$$

$$\Phi_{fm}^t \geq \Upsilon_{fpm}^t, \quad f = 1, \dots, F, \quad p = 1, \dots, P, \quad m = 1, \dots, M, \quad t = 1, \dots, T; \quad (4)$$

$$\Phi_{fm}^t \leq \sum_{p=1}^P \Upsilon_{fpm}^t, \quad f = 1, \dots, F, \quad m = 1, \dots, M, \quad t = 1, \dots, T; \quad (5)$$

$$\sum_{f=1}^F \Phi_{fm}^t \leq 1, \quad m = 1, \dots, M, \quad t = 1, \dots, T; \quad (6)$$

$$\sum_{p=1}^P \Upsilon_{fpm}^t \leq 1, \quad f = 1, \dots, F, \quad m = 1, \dots, M, \quad t = 1, \dots, T; \quad (7)$$

$$X_{klm}^{t+1} = \begin{cases} 0, & \Phi_{km}^t + \Phi_{lp}^{t+1} \leq 1, (k, l) \in F_1, m = 1, \dots, M, t = 1, \dots, T-1; \\ 1, & \Phi_{fjm}^t + \Phi_{fjm}^{t+1} = 2 \vee \Phi_{km}^t + \Phi_{lm}^{t+1} \leq 2, (k, l) \notin F_1, f_1 \in F, m = 1, \dots, M, t = 1, \dots, T-2; \end{cases} \quad (8)$$

$$\sum_{o=1}^O \sum_{f=1}^F \sum_{p=1}^P \sum_{t=k}^{k+\tau-1} P_{ofpm}^t \leq \rho_m^{\max}, \quad m = 1, \dots, M, \quad k = 1, \tau, 2\tau, \dots, T; \quad (9)$$

$$\eta_m^{\min} \cdot \Upsilon_{fpm}^t \leq \sum_{o=1}^O P_{ofpm}^t \leq \eta_m^{\max} \cdot \Upsilon_{fpm}^t, \quad f = 1, \dots, F, \quad p = 1, \dots, P, \quad m = 1, \dots, M, \quad t = 1, \dots, T; \quad (10)$$

$$\sum_{f=1}^F \sum_{p=1}^P \sum_{m=1}^M \sum_{t=\alpha_o}^T P_{ofpm}^t = 0, \quad o = 1, \dots, O; \quad (11)$$

$$X_{klm}^{t+1}, \Phi_{fm}^t, \Upsilon_{fpm}^t \in \{0, 1\}, \quad (k, l) \in F_1, \quad f = 1, \dots, F, \quad p = 1, \dots, P, \quad m = 1, \dots, M, \quad t = 1, \dots, T-1; \quad (12)$$

$$\Pi_{ofpm}^t \in \mathbb{Z}, \quad o = 1, \dots, O, \quad f = 1, \dots, F, \quad p = 1, \dots, P, \quad m = 1, \dots, M, \quad t = 1, \dots, T-1; \quad (13)$$

$$P_{ofpm}^t \geq 0, \quad o = 1, \dots, O, \quad f = 1, \dots, F, \quad p = 1, \dots, P, \quad m = 1, \dots, M, \quad t = 1, \dots, T-1; \quad (14)$$

The proposed optimization model pursues the minimization of five components as in (1). The first component represents the setup, regular cleaning and operating costs. The second component relates to costs of changeover between incompatible families. The third component penalizes the capacity utilization of machines. The fourth component represents an earliness penalty. The fifth component penalizes the number of assignments and it is complementary to the third component. Constraints set (2) ensure that the total demand will be covered by the production plan for a given planning horizon of T periods. Constraints set (3) ensure satisfaction of each order o . According to constraints (4) a family f is assigned to machine m during a production period t if at least one product that belongs to that family and an order o is produced on machine m in the same period. Moreover, constraint set (5) enforces the binary Φ_{fm}^t to be zero when no product p is produced on machine m in period t . We introduce a binary variable X_{klm}^{t+1} to denote a changeover from family k to family l ($(k, l) \in F_1$, F_1 is the set of incompatible pairs of families) on machine m in consecutive periods t and $t+1$. When X_{klm}^{t+1} is equal to 1, there is a need for cleaning

which takes two time periods. The cleaning activity is denoted by a dummy family f_1 . The cleaning activity can be avoided if there are two compatible pairs of product families that can be added (8). Constraint set (9) enforces upper bound on daily production for each machine m where daily production covers τ time periods. Upper and lower bounds on the production amount assigned to each machine in every time period t are enforced by (10). Since the approach does not allow delay in order fulfillment, constraint (11) enforces satisfaction of deadlines for each order (α_0). Finally, through constraints (12)-(14), binary, integer and continuous variables are defined.

NUMERICAL EXAMPLE

In this section a real-world case is explained and solved by the proposed MILP model. The scheduling time horizon for premix production is taken as 10 days. A time period has 68 minutes which is equivalent to a production cycle, one day includes 21 time periods approximately. There is a continuous production in three time shifts. There are five machines of various capacity and various daily production rate (Table 1).

Table 1. Set of machines, their capacities and production rates

Machine	A	B	C	D	E
Minimum Capacity	50	60	60	45	45
Maximum capacity	1000	1500	2000	500	160
Maximum daily production rate	16936	25404	33872	8468	2710

The set of eight orders that includes 61 product sorted in 13 families was subject of optimization. The total quantity that need to be assigned is 99289.6 kg. Cost parameters are defined as follows: $c_{fpm}^s = 15$ m.u., $c_{fpm}^o = 25$ m.u., $c_m^{ch} = 10$ m.u., $c_{fpm}^{ch} = 20$ m.u., $c_m^{ul} = 30$ m.u. The orders with a specific amount per product included are given in Table 2. The products belong to a set of 13 product families.

Table 2. Set of orders, ordered amounts by product and deadlines

Order	Product (quantity in kg)										Deadline day	Deadline hour
O1	P165	P35	P202	P50	P192	P231	P263	P90			3	10
	369	272	819	378	216	240	282	315				
O2	P4	P5	P124	P125	P126	P157					7	16
	630	8100	840	3780	504	200						
O3	P31	P32	P33	P36	P45	P49	P171	P237			5	8
	825	2160	1035	1800	7285	2720	5200	3080				
O4	P84	P86	P260	P122	P92	P149	P72	P56	P128	P10	5	8
	149.6	144	5056.8	2214	239.2	1400	594	72	15000	1914		
O5	P11	P152	P19	P30	P93						5	8
	120	460	150	150	1600							
O6	P188	P247	P254	P253	P74	P44	P141	P46			6	10
	117	3045	2100	1050	780	225	19500	663				
O7	P216	P218									7	7
	500	996										

Preferred bag sizes for each product are given in Table 3.

Table 3 Preferred bag sizes for each product

Product	P165	P35	P202	P50	P192	P231	P263	P90	P4	P5	P124	P125	P126	P157
Bag size	20.5	16	10.5	18	12	30	23.5	10.5	10.5	9	10.5	13.5	21	25
Product	P31	P32	P33	P36	P45	P49	P171	P237	P84	P86	P260	P122	P92	P149
Bag size	16.5	18	11.5	18	15.5	16	13	14	13.6	16	16.8	18	18.4	20
Product	P72	P56	P128	P10	P11	P152	P19	P30	P93	P188	P247	P254	P253	P74
Bag size	22	12	15	22	20	20	10	10	20	13	14.5	14	14	30
Product	P44	P141	P46	P216	P218									
Bag size	12.5	19.5	13	20	12									

The model was written in AMPL (IBM ILOG AMPL 12.10) modelling language and solved using CPLEX 12.2. The experiments were performed in a 2.6 GHz Intel Core i7-5600 with 8GB of RAM memory and Windows 10 Operating System. Total solving time is 257.7 seconds. The optimal production schedule is given in Table 4. More specifically, Table 4 gives the exact production level for every product in each production day taking into account the deadlines and preferred bag sizes. The outputs for two orders are given due to the space limitations.

Table 4 Production schedule

Order	Product	Machine					Production period	
		A	B	C	D	E	day	hour
O1	P165	369					3	10
	P35				272		3	9
	P202			819			3	10
	P50		378				3	10
	P192	216					3	9
	P231		240				3	9
	P263			282			3	9
	P90				315		3	10
O2	P4	630					7	15
	P5			612			7	13
			1494				7	14
				1998			7	14
				1998			7	15
				1998			7	16
	P124	840					7	16
	P125		783				7	12
			1498.5				7	15
			1498.5				7	16
	P126				441		7	16
		63					7	16
	P157				200		7	15

CONCLUSIONS

This work has analyzed a real problem of lot sizing and scheduling in a capacitated scenario, with parallel machines arising in a feed premixes production company. A MILP mathematical model was formulated and applied to a test case, taking into account capacity limitations, deadlines and compatibility between different product families. The results obtained with AMPL modelling language and CPLEX solver are satisfactory and encouraging for more in-depth computational work. Future research will be concentrated to addition of raw material and warehouse space limitations, soft deadlines, human operator limitations and transforming the model in a tool that will facilitate decision making in a feed premix manufacturing plant.

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Modelling and Optimization of the Real-life Crop Rotation Problem in Serbia

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Abstract

The study focuses on the real-life problem of crop rotation in Serbia. Searching for the most appropriate crop sequence has drawn attention for a long time, but the problems in literature differ from many aspects due to the different crops, soil, climate factors and their characteristics, available equipment, resources, demands of the farm management and many others. Therefore, the problem that we considered is a specific one and according to our knowledge cannot completely fit in the already developed mathematical models and proposed solution methods. From the aspect of the farm, the goal is to maximize the profit under specific constraints from practice: limited land area, lower and upper bounds of area under considered vegetables and crops, their characteristics and the appropriate order of sowing. The 0-1 nonlinear programming model is proposed and tested using exact Lingo solver. Optimal solutions are provided only for small-size instances that are generated following the structure of real-life instance with minor adapting of the input data to fit the smaller area field. In addition, an approximation of a solution of larger-size real-life instance is provided by dividing the total area into equal fields, considered as units of land instead of hectares. According to the obtained results, it can be concluded that developing an efficient metaheuristic method for the considered problem is a good choice in order to provide more precise, high quality solutions for larger-size instances. The results represented in this paper can be used as a benchmark for testing the performances of the future developed approximate solution methods.

KEYWORDS

Crop rotation, Optimization, Mathematical modeling, Agriculture

INTRODUCTION

Crop rotation problems are present in literature for a very long time since the production of essential food crops is crucial in life worldwide and its improvement is of a great importance from the aspect of agricultural progress, economy and business. This type of optimization problems appears as one of the first applications of linear programming due to the early work of Hildreth and Reiter (1951). Since then, a significant number of specific problems and study cases in this area have been published. However, due to the new research in crop science and technological progress, crop rotation problems constantly draw attention.

Sarker et al. (1997) developed a linear model for crop rotation problem in Bangladesh considering a planning horizon of 12 months, three different types of land and the defined sets of different crop combinations, with the goal to maximize the total contribution from cropping and importing crops. Another approach using network flow for a variant of crop rotation problem is proposed by Detlefsen (2004). A discussion of crop succession requirements from a mathematical point of view is provided by Haneveld and Stegeman (2005). Forrester and Rodriguez (2018) deal with crop rotation problem of a college organic farm. The authors considered four-year planning horizon divided into months including specifics of the available fields and irrigation system. The goal of the problem is to minimize the total unmet demand over the entire period, as university's farm is not profitable. A specific example of crop rotation modeling by 0-1 nonlinear formulation can be found in Li et al. (2015). As the exact solver failed to find feasible solution, authors designed a heuristic approach to maximize the profit under fair conditions for eighty smallholder farmers. More about modelling and review on crop rotation problems can be found at Dury et al (2012).

The considered problem differs in selection of crops, their characteristics, different time intervals, and specific demands. For the set of crops involved in our crop rotation problem, we identified periods of season instead of months. The plan

is not related to the specific fields, the farm has contracts and needs to meet all demands and, finally, the objective function value represents a profit that should be maximized.

PROBLEM DESCRIPTION

The real-life crop rotation problem that we consider has several specifics. There is a fixed available area of land that should be used completely. The plan should be determined as a four year cycle. Each one from the set of 14 different crops and vegetables cannot be sown more than once during the considered four year period at the same piece of land. Crops are characterized by their average yield per hectare, price on the market (in EUR/kg) and cultivation costs (in EUR/ha), estimated according to the experience, temporary conditions, available resources and equipment of the farm. In addition, for each crop there are two important periods of year, sown and harvested time windows, used to identify the three subsets of crops: *monoculture* crops, *main* crops and *stubble* crops. The first set, monoculture crops, includes the crops that are sown as a single-crop, meaning that they occupy the land during entire season. These are: potatoes, green beans1, sweet corn1, corn, soy and silage corn1. The second set, main crops, consists of: peas, oilseed rape, barley, rye and wheat, which are crops with earlier harvesting period, leaving an opportunity for semination the same land in the same year by one more crop from the third set, stubbled crops with the remaining three: green beans2, sweet corn2 and silage corn2. Therefore, in each year, each hectare can be sown by monoculture or just main crop or two crops: main and stubbled. Among these 14 crops the preceding order is declared as: *bad*, *medium* and *good*, taking into account experience with balance in soil nutrients, diseases and weed levels after harvesting of each crop. The minimum percentage ratio of area under good preceding crop order in each year is known in advance and should be provided, while bad preceding crop order should be forbidden. The goal is to maximize the total profit over the entire period and area of land, under the required conditions.

THE PROPOSED MATHEMATICAL MODEL

For the described problem, the 0-1 nonlinear mathematical programming model is proposed, using the following notation:

Table 1. Notation

Symbol	Description
m	The total number of crops
n	The total number of hectares
t_{max}	The total number of years
$I = \{1, 2, \dots, m\}$	The set of indices of crops
$J = \{1, \dots, n\}$	The set of indices of hectares
$T = \{1, \dots, t_{max}\}$	The set of indices of years
$I_1 \subset I$	The subset of monoculture crops
$I_2 \subset I$	The subset of main crops
$I_3 \subset I$	The subset of stubble crops
c_i	Yield (in kg/ha) of crop $i \in I$
p_i	Price (in EUR/kg) of crop $i \in I$
e_i	Cultivation costs (in EUR/ha) for crop $i \in I$
l_{it}	Lower bound of the number of hectares under crop $i \in I$ during year $t \in T$
u_{it}	Upper bound of the number of hectares under crop $i \in I$ during year $t \in T$
$G = [g_{ik}]$	Binary ($m \times m$) matrix defined by: $g_{ik} = 1$, if a crop $i \in I$ is a good preceding crop of $k \in I$, otherwise $g_{ik} = 0$
$M = [m_{ik}]$	Binary ($m \times m$) matrix defined by: $m_{ik} = 1$, if a crop $i \in I$ is a medium preceding crop of $k \in I$, otherwise $m_{ik} = 0$
Q_{min}	Minimum percentage of area under good preceding crops

The case when a crop $i \in I$ is bad preceding crop of $k \in I$ should be forbidden in crop rotation plan. Note that, having in mind definitions of matrices G and M , in this case both $g_{ik} = 0$ and $m_{ik} = 0$ stand.

The proposed model uses one set of binary variables x_{ijt} , defined in the following way. If crop $i \in I$ is sown at hectare $j \in J$ in year $t \in T$, binary variable x_{ijt} takes the value 1, otherwise $x_{ijt} = 0$ stands.

Using the above notation and the described problem characteristics, the following 0-1 nonlinear mathematical programming model is proposed:

$$(max) \sum_{(i,j,t) \in I \times J \times T} (c_i p_i - e_i) x_{ijt} \quad (1)$$

$$\sum_{i \in I_1 \cup I_2} x_{ijt} = 1 \quad \forall j \in J, \forall t \in T \quad (2)$$

$$x_{ijt} + x_{kjt} \leq 1 \quad \forall (i,k) \in (I_1 \cup I_3) \times I_3, i \neq k, \forall j \in J, \forall t \in T \quad (3)$$

$$\sum_{j \in J} x_{ijt} \geq l_{it} \quad \forall i \in I, \forall t \in T \quad (4)$$

$$\sum_{j \in J} x_{ijt} \leq u_{it} \quad \forall i \in I, \forall t \in T \quad (5)$$

$$x_{ijt} + x_{kj,t+1} \leq 1 + g_{ik} + m_{ik} \quad \forall i \in I_1 \cup I_3, \forall k \in I_1 \cup I_2, \forall j \in J, \forall t \in T \setminus \{t_{max}\} \quad (6)$$

$$x_{ijt_{max}} + x_{kj,1} \leq 1 + g_{ik} + m_{ik} \quad \forall i \in I_1 \cup I_3, \forall k \in I_1 \cup I_2, \forall j \in J \quad (7)$$

$$(1 - \sum_{k_1 \in I_3} x_{k_1 j t})(x_{ijt} + x_{kj,t+1}) \leq 1 + g_{ik} + m_{ik} \quad \forall i \in I_2, k \in I_1 \cup I_2, \forall j \in J, \forall t \in T \setminus \{t_{max}\} \quad (8)$$

$$(1 - \sum_{k_1 \in I_3} x_{k_1 j t_{max}})(x_{ijt_{max}} + x_{kj,1}) \leq 1 + g_{ik} + m_{ik} \quad \forall i \in I_2, k \in I_1 \cup I_2, \forall j \in J \quad (9)$$

$$\sum_{j \in J} \sum_{(i,k) \in I_2 \times I_3} (g_{ik} - Q_{min}) x_{ij1} x_{kj1} \geq 0 \quad (10)$$

$$\sum_{j \in J} (\sum_{(i,k) \in (I_1 \cup I_3) \times I_1} (g_{ik} - Q_{min}) x_{ijt} x_{kjt+1} + 0.5 \sum_{(i,k) \in (I_1 \cup I_3) \times I_2} (g_{ik} - Q_{min}) x_{ijt} x_{kjt+1} + 0.5 \sum_{(i,k) \in I_2 \times I_3} (g_{ik} - Q_{min}) x_{ijt+1} x_{kjt+1} + 0.5 \sum_{(i,k) \in I_2 \times I_2} (1 - \sum_{k_1 \in I_3} x_{k_1 j t})(g_{ik} - Q_{min}) x_{ijt} x_{kjt+1} + \sum_{(i,k) \in I_2 \times I_1} (1 - \sum_{k_1 \in I_3} x_{k_1 j t})(g_{ik} - Q_{min}) x_{ijt} x_{kjt+1}) \geq 0, \quad \forall t \in T \setminus \{t_{max}\} \quad (11)$$

$$\sum_{j \in J} (\sum_{(i,k) \in (I_1 \cup I_3) \times I_1} (g_{ik} - Q_{min}) x_{ijt_{max}} x_{kj1} + 0.5 \sum_{(i,k) \in (I_1 \cup I_3) \times I_2} (g_{ik} - Q_{min}) x_{ijt_{max}} x_{kj1} + 0.5 \sum_{(i,k) \in I_2 \times I_3} (g_{ik} - Q_{min}) x_{ij1} x_{kj1} + 0.5 \sum_{(i,k) \in I_2 \times I_2} (1 - \sum_{k_1 \in I_3} x_{k_1 j t_{max}})(g_{ik} - Q_{min}) x_{ijt_{max}} x_{kj1} + \sum_{(i,k) \in I_2 \times I_1} (1 - \sum_{k_1 \in I_3} x_{k_1 j t_{max}})(g_{ik} - Q_{min}) x_{ijt_{max}} x_{kj1}) \geq 0 \quad (12)$$

$$\sum_{t=1}^{t_{max}} x_{ijt} \leq 1 \quad \forall i \in I, \forall j \in J \quad (13)$$

$$x_{ijt} \in \{0,1\} \quad \forall i \in I, \forall j \in J, \forall t \in T \quad (14)$$

The objective function (1) represents the total profit that should be maximized, calculated as the sum of differences between the income and costs per each hectare over the entire period. Based on the costs and profit sharing obtained from the farm, we calculate the corresponding values for each crop per hectare.

Constraints (2) ensure that each hectare in each year must be sown by exactly one of the monocultures or main crops. As the stubble crop can be sown in the same year and at the same hectare after some main crop, we allow the two variables x_{ijt} and x_{kjt} to take the value of 1 for the same pair $(j, t) \in J \times T$, but only in the case when $(i, k) \in I_2 \times I_3$. To ensure this constraint correctly, in addition to restriction provided by (2), constraints (3) prevent this possibility in the case when one of them is monoculture and the other is stubble or both of them are different stubble crops i.e. $(i, k) \in (I_1 \cup I_3) \times I_3$ and $i \neq k$.

The purpose of constraints (4) and (5) is to ensure the lower and upper limits of area under each crop in each year. The constraint (6) provides that changing the crop between the two consecutive years t and $t + 1$ at the same hectare is conducted under good or medium preceding crop. Similar, constraints (7) refer to the connection between the last and the first year, with the purpose to ensure the appropriate order in repeating the cycle. Note that constraints (6) and (7) didn't cover the special case when the considered crop i is a main one ($i \in I_2$), due to the two possibilities in this case. Namely, crop $i \in I_2$ can be followed or not by a stubble crop in the same year and the same hectare. Good or medium preceding crop in both these cases is provided by constraints (8), while their modifications (9) handle the connection between the last and the first year of the considered period. Note that the expression in the first pair of brackets on the left side of constraints (8) is equal to 1 only when there is no stubble crop in year t and in this case (8) is active, otherwise the considered crop i is not directly preceding crop of k and (8) are neglected due to the non-negative right side.

Constraints (10)-(12) ensure the minimum ratio of Q_{min} of the total area under good preceding crop, having in mind that all sums include factor $g_{ik} - Q_{min}$ and the left side is required to be non-negative. Constraint (10) refers to the first year which involve only the preceding relation between main and stubble crops. Constraints (11) are more complex as they cover all possible consecutive semination between years t and $t + 1$, as well as during year $t + 1$, for $t \in T \setminus \{t_{max}\}$. In the case when there is a pair of main and stubble crop in year $t + 1$, we decided to refer 50% of the hectare to the relation between the preceding crop in year t and the main crop in year $t + 1$ and another 50% between main and stubble crop in year $t + 1$. The fourth sum, that is also taken into account as 50% of its area, covers the case when a main crop is not followed by stubble crop in year t . The first and the last of the five major sums for each hectare $j \in J$ in (11) are related to the order of semination in the case when there is a monoculture in year $t + 1$. Constraint (12) has the similar structure used to ensure the same condition between the last and the first year, providing the cycle in crop rotation. The purpose of constraints (13) is to provide that during the considered period each crop is not sown more than once at the same hectare. Finally, constraints (14) define the type of variables in model.

EXPERIMENTAL RESULTS

Experimental results using Lingo 18 solver are obtained by Intel Core i7-4578U processor on 3.00 GHz with 16GB RAM memory under Mac operating system. Lingo is an efficient tool for solving wide variety of optimization problems and its global solver is suitable for nonlinear models (Lindo Systems Inc.).

For testing the proposed model using Lingo Solver with the imposed time limit of 10 hours, we generated a set of 11 smaller-size instances, based on the real-life data obtained from the farm management. More precisely, all instances include the same set of crops with their characteristics (yield, price, cultivation costs, good and medium preceding order of crops), but with different total area of land (n) and different lower and upper bounds of the area under each crop in each year (l_{it} and u_{it} , $i \in I$, $t \in T$) chosen to fit in the total area. In preliminary experiments, we noticed that Lingo was more successful in solving instances where the total demands in each year cover less than half of the total area, i.e. $\sum_{i \in I} l_{it} < \frac{n}{2}$, for each $t \in T$. These instances are denoted by T_n . In the opposite case, more difficult instances are generated and denoted by T'_n .

Experimental results are represented in Table 2 that is organized in the following way. The first column contains the name of instance. Optimal solution and Lingo running time (in seconds) are represented in the next two columns, while in the case when Lingo didn't reach optimal solution for 10h, the lower and upper bounds for the objective function value, if obtained, are shown in columns LB and UB, respectively.

Table 2 Experimental results using Lingo 18 solver

Instance (T_n/T'_n)	Optimal solution		Feasible solution	
	Obj. fun. value	Time(s)	LB	UB
T_{10}	45574.70	565.02	/	/
T'_{10}	/	/	43132.20.	43649.02
T_{15}	68289.30	1434.42	/	/
T'_{15}	/	/	63887.00	64932.68
T_{20}	/	/	90765.00	91166.10
T'_{20}	/	/	85531.25	87635.74
T_{25}	/	/	111792.80	112254.70
T'_{25}	/	/	109102.00	110287.10
T_{30}	/	/	135307.90	135646.90
T'_{30}	/	/	130180.50.	131820.50
T_{35}	/	/	/	/

As it can be noticed from Table 3, Lingo solved only two instances (T_{10} and T_{15}) to optimality and for the 8 of the remaining instances it provided feasible solutions with the objective function value represented in column LB. The exception is the last instance (T_{35}) without feasible solution for 10h of running time. All deviations of LB from the corresponding UB values are less than 2.5% on this set of instances, indicating a good quality of the obtained feasible solutions.

From the experimental results on the set of generated instances it can be concluded that Lingo can provide feasible solutions for test examples up to 30 ha. Having in mind that real-life instance refers to the total area of 981ha, we rounded this value and all demands (l_{it}, u_{it} , $i \in I$, $t \in T$) to the nearest 50ha. Then, we divide the rounded total area of 1000ha into 20 fields of 50ha, as well as values l_{it} and u_{it} . In addition, we multiply each yield and cultivation costs

(values c_i and e_i , $i \in I$) by 50 to represent the yield and costs of a field instead of a hectare. The rest of the input data remain the same, representing the real-life data, as noted above. With the imposed running time of 10h, Lingo obtains feasible solution on such transformed real-life instance with the corresponding lower and upper bounds of 4483540 and 4495438, respectively. Lingo couldn't provide better feasible solution even with the extension of running time to 20h. This approximation of the problem solution obtained by dividing the area into the equal fields of 50ha can be practically implemented with further small adaptations. However, the limitations of exact Lingo solver lead to the conclusion that development of a heuristic method is a good choice in searching for more precise solution of the considered real-life instance.

CONCLUSIONS

The real-life crop rotation problem is considered and modelled. The proposed 0-1 nonlinear mathematical model is tested using exact Lingo solver and the solutions (optimal or feasible) are obtained on the set of generated smaller size instances. Having in mind the limitations of exact solver, the significantly larger real-life instance is transformed using equal fields instead of hectares and approximately solved. The obtained feasible solution, close to the corresponding upper bound, can be used in practice. However, for providing the precise solution it's necessary to develop an efficient metaheuristic approach. Another direction of the future research is to investigate the complexity of the problem.

ACKNOWLEDGEMENT

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A methodological approach for minimize the transportation cost-time regarding responses to natural disasters

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Abstract

The research work is intended to be a deterministic approach which minimizes the cost-time in a transportation problem. The most adequate way for the optimization of a transportation problem is to utilize a Linear Programming methodology. So, the problem is modeled as a Linear Programming (LP) problem where the demand, the supply and the transportation cost-time per unit are considered known. In this paper a real world case study of a transportation problem involving the transfer of patients, concerning a disaster to the nearest Hospitals is utilized for the illustration of the proposed approach. This case includes three distinct features. The first one refers to the limited transportation resources (ambulances) which leads to multi transports of the ambulances, the second is related to the different significance and emerging of the patients which provides a need for prioritization of the cases and the last to the limits resources of the beds in the hospitals located in different areas.

KEYWORDS

Linear Programming, Transportation Time, Optimization.

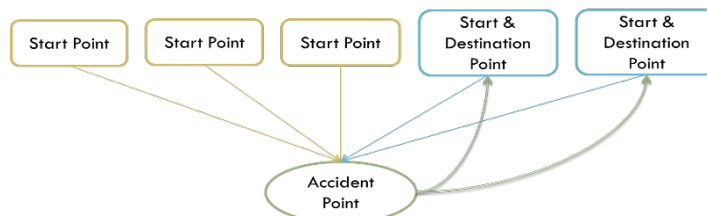
INTRODUCTION

The transportation time is crucial pertaining to the successful confronting of accidents. This category also includes the case of ambulance fleet management for the transportation of patients in the event of an accident with multiple injuries (Accident Point).

This case can be more complicated for some reasons. First of all, there are multiple start points of ambulance fleet and multiple destination points which are the nearest Hospitals for the arriving ambulances. Also, some ambulances have to make more than one transportation to a different destination point. Each destination point for a selected ambulance is the start point on the next round. There is an uncertainty considering the time it takes for ambulances to transport patients at the nearest Hospitals. People who are seriously injured take precedence over others who are slightly injured. Last but not the least, there is a limited number of beds in each hospital.

Furthermore, some assumptions had to be made. First of all, there are no extra accidents on different places which needed the immediate mobilization of the ambulance fleet to that location. All beds of each hospital are available. There is only one specific place with injured people. At the beginning, there is a specific number of ambulances on each start point. There is a specific number of patients which can be served on every turn by the Hospitals. There is a specific number of patients which can be transported on every turn by the ambulances.

On the below diagram the problem is visualised.



Actually, the case can be categorized in the logistic problems, but a little quirky. That's why an approximate approach is provided. The research in this field is on progress and the next step is to move forward to the examination of the Dynamic Programming features. Furthermore, we utilize simulation process in order to picture and investigate the solutions provided by the LP approach.

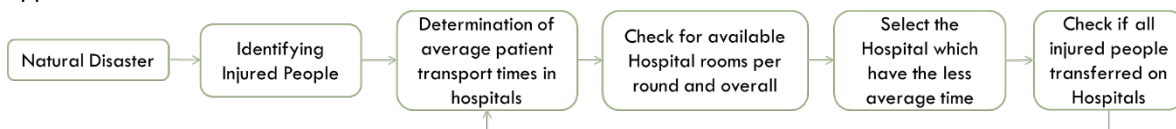
LITERATURE REVIEW

Generally, there are several studies which provide representative solutions for these problems by Deshabrata Roy Mahapatra (2013), and Chakraborty Ananya (2010), because in real world applications, the supply and the demand per unit of the quantities are generally not specified precisely and the parameters are fuzzy in nature. A heuristic solution method was also provided by Leon Cooper (1978), and Alireza Amirteimoori (2011) since the supply, and the demand were random variables with some given probability distribution because decision makers can have a lot of different aims to achieve for each possible shipment and these aims may be in conflict with each other. But, all the above studies have the same disadvantage. They know exactly the cost but they do not know precisely the supply and the demand.

On the other hand there are several authors such as Hammer (1971) Garfinkel and Rao (1971), Szwarc (1971), Bhatia, Swarup and Puri (1976), Ramakrishnan (1977), who tried to minimize the Time cost of the transportation because they believed that it was high important. On our case, in real life applications, the most difficult thing is to determine the exactly time for the transportation which is needed by the ambulances to transport the patients to the nearest Hospitals due to the traffic or other parameters. That is why their own thinking will be followed by us because all the necessary information is already known.

METHODOLOGY

As per Ben Janse (2018), taking decisions based on multiple different criteria with help from the Multiple Criteria Decision Analysis (MCDA) tool can then make things clear. The below diagram presents the workflow of the proposed approach.



MATHEMATICAL FORMULATION OF METHODOLOGY

It is supposed that there are m start points (for the ambulances) and n destination points (Hospitals). It is assumed that the quantities available (ambulances) at the starting points, demands at the destination points and the time cost per unit of the quantity are given precisely. In addition, it is assumed that it is possible to transport the patients from any start point to any destination point and every turn only m patients can be transported to the Hospitals by the ambulances.

Let C_{ij} be the time cost of transportation of one patient from start point i to the destination j , M_j be the number of patients who can be served by the destinations j , A_j be the number of patients who were served by the destinations j , L_j be the maximum number of patients which can be served by the destination j , and X_{ij} be the number of patients transported from start point i to the destination point j . The objective is to minimize the total time cost of transportation taking into account all the constraints.

The mathematical formulation of this linear programming problem may be presented as follows:

Find $X_{ij} \geq 0$ ($i = 1, 2, \dots, m; j = 1, 2, \dots, n$) to

Minimize

$$f(x) = \sum_{i=1}^m \sum_{j=1}^n (C_{ij})(X_{ij}) \quad \text{where } X_{ij} \in \{0,1\}$$

Subject to the constraints:

$$\sum_{j=1}^n A_j \leq \sum_{j=1}^n M_j \quad \sum_{j=1}^n A_j = 5 \quad M_j \leq L_j$$

The model applies when the total availability exceeds the total demand.

In addition, in each new turn applies that the final time cost is equal with the previous final time cost plus the necessary change to be made in this round. Last but not the least, the final number of patients who were served by the destinations is equal with the previous final number of patients who were served by the destinations plus the necessary change to be made in this round.

$$\sum_{i=1}^{m_1} \sum_{j=1}^{m_2} C_{ij} = \sum_{i=1}^{m_1} \sum_{j=1}^{m_2} C_{i-1,j} + \sum_{i=1}^{m_1} \sum_{j=1}^{m_2} C_{ij}$$

$$\sum_{j=1}^n M_j = \sum_{j=1}^n M_{j-1} + \sum_{j=1}^n M_j$$

Furthermore, patients are classified based on the severity of their injury and are transported in order of priority from the heaviest patient to the lightest.

ILLUSTRATION

On our case, we made an assumption that we have (6) six start point and (3) terminal point (Hospitals). At the beginning, there are (2) ambulances on each start point. Moreover, we made an assumption that we have only 15 patients who are classified based on the Australasian Triage Scale (ATS) (Alister Hodge, 2013). Also, we have to make (3) three turns/phases in order to transport everyone on the nearest Hospitals because we assume that we can transport only five patients per turn.

On the below table the results of this process can be presented.

	Hospitals		
	Athens M. C. (M1<=24)	Pentelis (M2<=6)	Sismanoglio (M3<=12)
People who served by the Hospitals	9	3	3
Maximum Capacity	24	6	12

All constraints are already satisfied and (9) nine ambulances will go on Athens Medical Center, (3) three ambulances will go on Pentelis Hospital and (3) three ambulances will go on Sismanoglio Hospital.

Furthermore, the route of the ambulances will be the bellow:

	Route of Ambulances	Treatment acuity (max wait time) (A)	Transportation Time (B)	A/B (have to be >= 1)
1-5	Spata - Rafina - Athens M.C.	0 minutes	48,5	0,00
	Spata - Rafina - Athens M.C.	0 minutes	48,5	0,00
	Athens M.C. - Rafina - Athens M.C.	10 minutes	55	0,18
	Athens M.C. - Rafina - Pentelis H.	10 minutes	61,5	0,16
	AIA - Rafina - Sismanoglio H.	10 minutes	66,5	0,15
6-10	Gerakas – Rafina - Athens M.C.	10 minutes	58,5	0,17
	Pentelis H. - Rafina - Athens M.C.	30 minutes	61,5	0,49
	Pentelis H. - Rafina - Athens M.C.	30 minutes	61,5	0,49
	AIA - Rafina - Pentelis H.	60 minutes	63,5	0,94
	Gerakas - Rafina - Sismanoglio H.	60 minutes	68	0,88
11-15	Sismanoglio H. - Rafina - Athens M.C.	60 minutes	64,5	0,93
	Sismanoglio H. - Rafina - Athens M.C.	120 minutes	64,5	1,86
	Spata - Rafina - Athens M.C. – Rafina - Athens M.C.	120 minutes	103,5	1,16
	Spata - Rafina - Athens M.C. – Rafina - Pentelis H.	120 minutes	110	1,09
	Athens M.C. - Rafina - Athens M.C. – Rafina - Sismanoglio H.	120 minutes	119,5	1,00

Simulation

The same case was illustrated by a software simulation with the name “Anylogic”. When we programed all the parameters, we had the below outcome.

	Route of Ambulances (with Anylogic)	Treatment acuity (max wait time) (A)	Transportation Time (B)	A/B (have to be ≥ 1)
1-5	Spata - Rafina - Sismanoglio H.	0 minutes	41,53	0,00
	Pentelis H. - Rafina - Pentelis H.	0 minutes	47,51	0,00
	Athens M. C. - Rafina - Sismanoglio H.	10 minutes	48,65	0,21
	Sismanoglio H. - Rafina - Pentelis H.	10 minutes	53,60	0,19
	AIA - Rafina - Sismanoglio H.	10 minutes	53,91	0,19
6-10	Athens M. C. - Rafina - Pentelis H.	10 minutes	88,84	0,11
	Pentelis H. - Rafina - Athens M. C.	30 minutes	95,55	0,31
	AIA - Rafina - Pentelis H.	30 minutes	100,83	0,30
	Sismanoglio H. - Rafina - Pentelis H.	60 minutes	102,18	0,59
	Spata - Rafina - Sismanoglio H. - Rafina - Sismanoglio H.	60 minutes	106,67	0,56
11-15	Athens M. C. - Rafina - Sismanoglio H. - Rafina - Athens M. C.	60 minutes	141,93	0,42
	Pentelis H. - Rafina - Pentelis H. - Rafina - Athens M. C.	120 minutes	143,59	0,84
	Pentelis H. - Rafina - Athens M. C. - Rafina - Sismanoglio H.	120 minutes	150,20	0,80
	AIA - Rafina - Sismanoglio H. - Rafina - Athens M. C.	120 minutes	153,91	0,78
	Sismanoglio H. - Rafina - Pentelis H. - Rafina - Sismanoglio H.	120 minutes	160,12	0,75

CONCLUSIONS

In this paper an effort has been made to develop a model to minimize the transportation time cost. Also, we examined how the transportation time cost changes on every turn and the route of every ambulance which will minimize the total transportation duration for the patients. Moreover, following this process we can find ways so that the patients can be transported faster to the nearest Hospitals minimizing the danger to lose someone his life. This methodological approach has been illustrated with a case study which provides us the most adequate solution for this transportation problem. Finally, an indicator developed provides the relationship between the treatment acuity and the transportation time which each ambulance need.

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Session 5:
Supply Chain Management and Logistics
chair: Sotiris Gayialis

Dual level assessment framework to evaluate feasibility and support decisions for the development of Natural Gas distribution facilities

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Abstract

This paper deals with the sustainability assessment to evaluate feasibility of Natural Gas distribution facilities projects in terms of economic, social and environmental issues affected the decision process and the project development strategy. By a system of system approach key cost and benefits variables are highlighted and a series of key performance indicators are presented. The evaluation framework based on balance scorecard to define the level of compliance with local socioeconomic expectations and project financial viability and attractiveness. Conventional wisdom is to present a coherent and easy to handle assessment framework appropriate to provide essential results to decision makers and investors towards Natural Gas distribution projects resiliency and sustainability.

Keywords: Energy Management, Energy Policy and Planning, Environmental Impact Assessment, Energy economy.

INTRODUCTION

As the need for a more sustainable and decarbonized future is continuously growing (Dester et al., 2012) natural gas has become the fastest growing primary energy source in the world, due to its environmental friendly nature and its multiple uses across a number of sectors. In Europe, the demand for natural gas is rapidly increasing, reaching 538 bcm in 2018. While the demand is growing so fast, the necessity for more expanded and well-developed natural gas distribution infrastructure is rising as well. Currently, Europe has a quite large natural gas distribution infrastructure, where countries such as Belgium, France, Germany, Norway, Italy the Netherlands and the UK have the best-developed distribution network. However, Russia and Norway remain the main natural gas suppliers to the remain European countries, since combined they provide almost 2/3 of the natural gas supplied to the EU (Dediu, Czajkowski, & Janiszewska-Kiewra, n.d.), in contrast to Portugal, Greece and Northern Ireland, that began to develop their NG distribution network during the latter half of the 1900s, (Correljé, 2016).

Natural gas was brought in Greece during 1997, therefore its distribution networks are still not fully developed. Currently, its National Natural Gas Distribution System consists of the main natural gas distribution system, which spreads through transmission pipelines and branches across the biggest part of the country, the Trans Adriatic Pipeline (TAP), an 878 km long pipeline, that will transfer natural gas to Europe from the Caspian region through Greece, Albania and Italy and also the under construction IGB and IGI distribution pipelines, which will be natural gas interconnector spreading from Bulgaria to Komotini Greece and from Turkish – Greek boarder to Italy, respectively.

This paper deals with the sustainability assessment and evaluation of the feasibility of Natural Gas distribution facilities project. The application of the proposed methodology framework is the Alexandroupolis Independent Natural Gas System (INGS) project.

METHODOLOGY FRAMEWORK

Socioeconomic development is defined as a multidimensional topic affecting many aspects of people's lives, directly, linked with the business sustainable development of business. Evidence on this is that the international organizations, which provide dedicated activities to promote the goals of sustainable business development (ITF 2017; UNECE, 2015; UNDP, 2014; OECD, 2013).

Sustainability has become a key priority for every operational process and has mainly three pillars: economic, environmental, and social as shown in figure 1. The feasibility evaluation of the Natural Gas distribution project in Alexandroupolis is assessed based on these three pillars and includes a variety of different factors that are assessed in order to obtain a conclusion on the sustainability of this project.

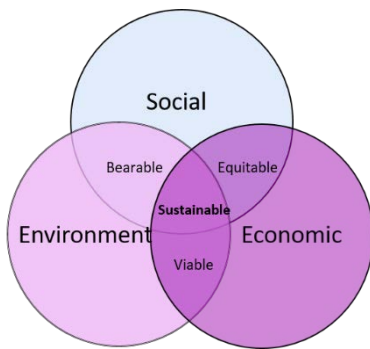


Figure 1. Sustainability Pillars

Economic assessment framework

A fundamental part of evaluating the feasibility of the project is conducting an economic assessment, which aims to examine the expenses and the costs occurring during the development of the project. After determining the different costs and expenses, Payback Time and ROI have to be calculated. Payback time is the time it takes a project to repay its initial investments and it is an effective criterion in evaluating the economic viability of a project. Therefore, the smaller the payback time is the quicker the project will generate a profit and will awake the interest of various investors. This payback time method assumes that all the investment is made in year zero and revenues begin immediately. Therefore, it may be assess whether a project can generate a profit or not, but it can be a trusted criterion of its profitability. Return on Investment (ROI) is a performance measure used to evaluate the efficiency of one or several investments and evaluate the financial consequences of investments and actions. When a ROI turns out to be negative that suggests that the total cost overcomes the return and so the project will generate a loss instead of a profit and an investment should not be made. On the other hand, when a ROI is positive, then the project is a success and the bigger the ROI is, the more probable is for a company to produce a profit.

Balance scorecard

Performance indicators support the management of infrastructures. As no single performance indicator can give a full picture regarding infrastructure performance, each indicator presents a partial view from a specific viewpoint and is therefore not enough to serve as a basis for management decisions. A popular performance measurement scheme suggested by Kaplan and Norton (1992) is the Balanced Scorecard (BSC) that developed to measure performance metrics from financial, customer, internal processes and growth perspectives. By combining these different perspectives, BSC helps decision makers to understand the inter-relationships and trade-offs between alternative performance dimensions, thus leading to improved decision making and problem solving. (Rajesh et al., 2012). The base point of BSC would be the identification of the unit's strategic plan. This would involve the development of a goals, strategy, outputs, measures, targets and four different financial perspectives (Kaplan and Norton, 1993;1996).

APPLICATION

Overview of the project

This project comprises an offshore floating unit for the reception, storage and re-gasification of LNG and a system of a subsea and an onshore gas transmission pipeline through which the natural gas is shipped into the Greek National Natural Gas System (NNGS) and onwards to the final consumers. The Alexandroupolis INGS has also the capacity to connect with and transmit gas into other gas transmission systems such as TAP (gas trade , 2013). This assessment framework will be based on the evaluation of the three economic, social and environmental Pillars.

Greece NG submission system

Natural Gas is, along with the petroleum products, the second biggest energy source used in the 21st century (Commission, 2018), while the natural gas market of Greece, the total consumption of natural gas for 2017 was 4,9 billion cubic meters (bcm), while the prediction for 2028 is to be increased in 6,2 bcm [5]. Greece is fully dependent in natural gas imports, since consumes in a year 5.0 times more than its total reserves. It sustains this consumption by importing 175,727 MMcf of natural gas per year (in 2017) (worldometer, 2017).The entrance points are three: the entrance point of Sidirokastro in Greece to Bulgaria borders, the entrance point of Kipoi in Greece to Turkey borders

and the Revithousa LNG land-based terminal. In 2017, the percentages of natural gas supply participation for the three entrance points mentioned above are 58,7%,12,4% and 28,9%, respectively.

The Alexandroupolis FSRU Station

The Alexandroupolis FSRU Station has been decided to be the 4th entrance point of Greek’s natural gas market. The capacity of its storages will be 170.000 cubic meters (cm), while the regasification capability will be 6, 1 bcm per year. The main component of the Project will be the offshore Floating Storage and Regasification Unit LNG vessel, with 300m length, 32,5m breadth and 26,5m height, which will be anchored at a fixed location at a distance of 17,6km southwest from the port of Alexandroupolis. The Project will also consist of the permanent offshore installations and the subsea and onshore sections of the gas transmission pipelines, which will be 24km and 4km long respectively. The pipeline of the FSRU station will be connected to the Greek natural gas transmission system in Amfitriti Station. (gas trade , 2013)

The FSRU Station is a cornerstone for the establishment of a gas hub in the area, since it will supply the Greek gas market, the Bulgarian and Balkan gas market via the IGB pipeline and the Italian market through the TAP pipeline.

Analysis results

The capital expenditures used for both calculations were taken from the study conducted by Brian Songhurst for Oxford University: “The Outlook for Floating Storage and Regasification Units (FSRUs)” (Songhurst, 2018). The capital expenditures for FSRU stations construction are shown in Table 1.

	Cost (mil €)
New FSRU Vessel Cost	223,3
Infrastructure cost	98,25
CAPEX	321,55
Contingency (10% of CAPEX)	32,15
Owner’s Cost	48,25
TOTAL CAPEX	401,95

Table 1: Capital expenditures for FSRU Station construction

The operational expenses were taken from the September 2016 press kit of the Toscana FSRU Station in Italy (Toscana, 2016) and Wartsila official website (Norrgård, 2018) and were estimated at 38,58 mil € per year. The charge rates (€/cubic meter) were taken from the study of Brian Soghurst (Songhurst, 2018) and the official website of Toscana FSRU Station (OLT, 2018) and are presented at Table 2.

FSRU Station	Charge rate (€/cm)
Indonesia	0,034
Lithuania	0,026
Chile	0,022
Italy	0,039

Table 2: Charge rates of FSRU Stations around the world, (for all the above calculations we applied the dollar – euro exchange rate of 1st May 2019 (0,8929 \$/€).

The benefits of the operation of FSRU station were studied both at national and local level. Primarily, at national level the station will contribute to the Greek gas market security, becoming the fourth entrance point of Greek national gas transmission system. With Turkey stopping the supply of natural gas through the pipeline from Bulgaria at the end of 2019, 80% of natural gas will come to Greece from pipelines that cross Turkey. Therefore, the necessity of an extra entrance point is extremely high. Also, it will strengthen the geostrategic position of Greece in the Balkan area. The FSRU station will feed the Bulgarian gas market through the IGB pipeline and feed gas to other countries as well, such as Serbia, North Macedonia, Romania and Hungary.

On the other hand, at a local level the benefits would be 120 new job positions and supply of services from local companies, that are expected to cost at around 20 mil € per year . (Toscana, 2016). Increase at the earnings of local companies from the professional tourism. The economic impact of the professional tourism is estimated to be from 187.500€ to 457.500€ per year. Last but not least, the FSRU station will have positive impact to the environment, due to the lower carbon and sulphur emissions of natural gas compared to diesel and coal [1]. The project shall also have

zero effect on the sensitive ecosystem of the Evros river delta and shall be located far from any Natura 2000 area. To ensure this, systematic monitoring for marine, physical, biological and eco-toxicological surveys shall be carried out.

CONCLUSIONS

Access to energy resources, energy supply security, insufficient investment in energy distribution infrastructure and sluggish progress in mitigating CO₂ emissions are wide recognized in the market. The evaluation of the efficiency of energy distribution project should analyses the impacts in above issues and in literature there is a lack of publication regarding multidimensional assessment. This paper present the outline of methodology and assessment framework on evaluation the feasibility of an energy distribution system by adopting a system of system approach.

While most economics accept the importance of sustainable development and social justice within and between generations, they also point to historical experience suggesting that decisions about new infrastructure should meet the social targets toward welfare. On the investors side energy market prices are key driver for efficient energy facility projects as in the concept most of them are capital intensive projects meaning some times the payback period is too long. Risk assessment assumptions and energy market forecasting its crucial in the feasibility study and this paper provides some key highlights in this area.

The weight of the socioeconomic outputs versus project financing factors and project overall cost in real decisions depends on the local goals, priorities and conditions, which should be reviewed independently for each case could be also considered for further research. In the numerical application should be given an extremely high weight in the decision of the projects implementation, because of the financial stress conditions in the given economy resulting high unemployment rates and economic recession in national scale. However, the estimation of the level of importance in the decision making for various options is an interesting area for further research .

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A case by case dual sourcing inventory model subject to different types of supply uncertainty

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Abstract

Supply disruption is a common phenomenon causing not only firms operational problems but also social problems. Many mitigation and contingency strategies have been studied extensively in the literature, highlighting the importance of efficient inventory management (i.e. safety stock, split order among multiple suppliers, use a backup supplier). Usually, using a mix of these strategies is preferable as it can lead to significant cost reduction and maintenance of firm reputation and improve stock management. Consequently, many researchers have studied the option of having a primary unreliable supplier with supply disruption risk and a backup, reliable, but more expensive one, in case of supply disruption in the primary. However, in many cases, the backup supplier may procure counterfeit or imperfect quality items. For example, during COVID-19 pandemic, Spain announced that it would return 640000 rapid testing kits it had imported, as (after tests on a batch) had found them to have a 30% defection rate (<https://www.euronews.com>). In the present paper, a continuous review inventory system where supply process is subject to two types of uncertainty, imperfect quality and disruption, is studied. The supply from the primary supplier is subject to sudden interruptions, so, in case of disruption, a backup supplier is used in order to prevent shortages. However, a batch from the backup supplier may contain a random percentage of counterfeit or imperfect quality items which are detected using an 100% and error-free screening process. The objective is the minimization of the total cost of the system per unit time, which is derived using renewal theory. Through numerical results, the impact of the quality uncertainty in this mixed type strategy is examined.

KEYWORDS

Inventory, counterfeit, imperfect, disruptions, supply uncertainty

INTRODUCTION

Supply uncertainty is an undesirable but, in many times, unavoidable phenomenon that firms must deal with. There are several different types of supply uncertainty including supply disruptions and imperfect product quality.

Supply disruption is related to sudden interruptions (endogenous or exogenous) in the supply causing, among others, lost sales and damage to firm reputation (Hendricks and Singhal, 2005; BCI supply chain resilience report 2018). The main characteristics of supply disruptions are: (1) their unpredictability and (2) their affections not only on the disrupted firms, but also their side affections in cooperative (with the disrupted) companies. In 2014, typhoon Halong hit South-eastern Asia causing, according to Apparel, more than 10 billion dollars not only in firms of these region, but also firms of other regions (Gao et al., 2019).

Many mitigation and contingency strategies have been studied extensively in the literature, highlighting the importance of efficient inventory management, including safety stock, split order among multiple suppliers, use a backup supplier (Tomlin, 2006). Parlar and Berkin (1991) introduced interruptions of the supply process, studying an EOQ-type model where supplies are available during a number of periods, while they are unavailable throughout the subsequent number of periods. A correction of this model was later provided by Berk and Arreola-Risa (1994). Parlar and Perry, 1995, as well as Heimann and Wagge, 2007, studied a continuous-review inventory model with deterministic demand assuming non-zero (positive) safety stock, while Konstantaras et al., 2018, studied a model with non-zero safety stock assuming periodic-review of the inventory. Parlar and Perry, 1996, and Gürler and Parlar, 1997, studied models with supply disruption assuming splitting orders among multiple suppliers. Qi, 2013, studied a continuous-review inventory model assuming the option of using a backup supplier when the primary is disrupted. In doing so, the decision maker has the capability to prevent non-desired shortages. In their model, the backup supplier is assumed to be more expensive but fully reliable. Reviews of related literature has been provided by Schmitt et al., 2015 and Snyder et al., 2016. However, in many cases, the backup supplier may procure counterfeit or imperfect quality items. During COVID-19 pandemic, Spain announced that it would return 640000 rapid testing kits it had imported, as (after tests on a batch) had found them to have a 30% defection rate (<https://www.euronews.com>). Many papers in the existing literature have dealt with the issue of receiving defective items. Salameh and Jaber, 2000, studied a model assuming that each batch

may contain a random percentage of defective items, which are detected during a screening period. The screening process is assumed to be 100% and error-free, with a finite screening rate. Since then, the paper of Salameh and Jaber has been revisited and extended in several directions: assuming learning in the percentage, learning in inspection, non-zero reorder level or allowing inspection errors. Review of models with imperfect quality items is given in Khan et al., 2011.

Wagner et al., 2019, refer that there is evidence that link supply disruptions with counterfeit risk assuming that this may be due to "the pressure to keep customers supplied even when trusted sources are unavailable". Counterfeit and imperfect quality does not have only financial impact. In some cases (for example in pharmaceutical products) it is vital. Inspecting a batch can reduce returns, ensure high quality and protect consumers from side effects. Usually, using a mix of mitigation strategies is preferable (as one strategy can cover the disadvantages of another) and it can lead to significant cost reduction, maintenance of firm reputation and stock management improvement.

ASSUMPTIONS AND NOTATION

In this section, the notation and the assumptions, under which the model is developed, are introduced.

Notation

Notation

S_1	Order up to from primary supplier [decision variable]	F_1	Fixed ordering cost from primary supplier
Q	Order quantity from the backup supplier [decision variable]	F_2	Fixed ordering cost from backup supplier
s	Reorder point [decision variable]	a_1	Unit purchase cost from primary supplier
l	Length of waiting period [decision variable]	a_2	Unit purchase cost from backup supplier
p	Percentage of defective items in a batch	h	Holding cost per unit per unit time
f_p	pdf of p	v	Selling price of imperfect item (per unit)
D	Demand rate	λ	Disruption rate
x	Screening rate	μ	Recovery rate
		z	D/x

2.1.1 Assumptions

1. The planning horizon is infinite.
2. The demand rate D is known and constant.
3. The lead time is zero.
4. There are two suppliers. The primary supplier (PS) faces random disruptions. The supply becomes unavailable at random points in time for a random duration. The time in which the supply is available follows an exponential distribution with a rate λ . The time in which the supply is unavailable follows an exponential distribution with a rate μ .
5. If a supply disruption occurs, the retailer waits for l time units for PS to become available (Qi ,2013). This period will be called waiting period. If PS becomes available in this period, an (s, S_1) is followed.
6. The length of the waiting period is at most equal to the time needed for the depletion of the safety stock, i.e. $l \leq \frac{s}{D}$.
7. If PS does not recover during the waiting time, an emergency order of size Q is placed from a backup supplier (BS). The product quality of the backup supplier is not reliable. Each lot from the backup supplier contains a random percentage p of low-quality products with a known probability density function f_p , independent of Q . The percentage of low-quality products in an emergency order is independent of the percentage of low-quality products in other emergency orders. The time between two consecutive successful orders from the primary supplier is defined as a cycle and it is of length T .
8. Each lot from BS is subjected to 100% and error-free screening process at a finite rate $x > D$.

9. In each cycle, the number of perfect quality products Y_Q is at least equal to the demand during the screening process with probability 1, i.e. $P(Y_Q \geq \frac{DQ}{x}) = 1$.
10. The low-quality products are sold as a single batch, to a secondary market at the end of the screening process.
11. The holding cost h per unit per unit time is the same for perfect and low-quality products.

MATHEMATICAL FORMULATION

In order to derive TC , Renewal Reward Theorem will be used. Therefore, the expected total cost per cycle and the expected cycle length must be derived.

To this end, the transition probabilities must be calculated. Define $P_{ij}(t)$ the probability that PS is in state j at time t given that PS was in state i at time 0, where i, j in $\{0,1\}$ and

state 0: PS is available,

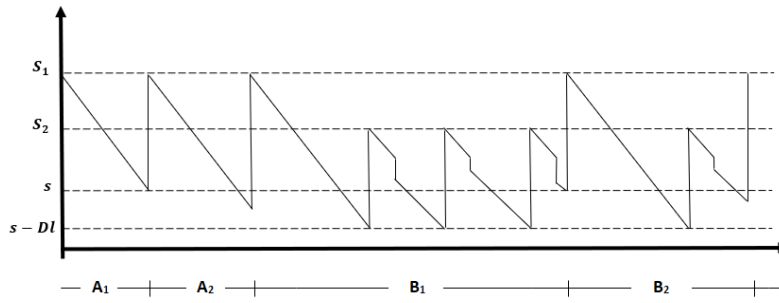
state 1: PS is not available

Then, since the probability of a disruption to occur during time interval of length dt is $\lambda dt + o(dt)$ and the probability of a recover to occur during time interval of length dt is $\mu dt + o(dt)$:

$$P_{01}(t) = \frac{\lambda}{\lambda + \mu} [1 - e^{-(\lambda + \mu)t}] \quad (1)$$

$$P_{10}(t) = \frac{\mu}{\lambda + \mu} [1 - e^{-(\lambda + \mu)t}] \quad (2)$$

The graphical representation of the inventory level



Following from the assumptions of the model, four different types of a cycle can occur, which are presented at figure 1. In the first type (named type A_1), the retailer orders up to S_1 from PS when the inventory level drops to s and the order is obtained immediately. In order cycle type A_1 to occur, PS must be available when the inventory level drops to s , which happens with probability $1 - P_{01}\left(\frac{S_1 - s}{D}\right)$. In the second type (named cycle type A_2), PS is not available when the inventory level drops to s , (the probability of non-availability is $P_{01}\left(\frac{S_1 - s}{D}\right)$) but recovers during the waiting period (the probability of recovery during the waiting period is $(1 - e^{-\mu l})$). So, an order up to S_1 is obtained as soon as PS recovers. In the last two cycle types (named type B_1 and B_2), PS is not available when the inventory level drops to s (the probability of non-availability is $P_{01}\left(\frac{S_1 - s}{D}\right)$) and does not recover during the waiting period (the probability of non-recovery during the waiting period is $e^{-\mu l}$). Hence, at the end of the waiting period, an order of size Q is placed from BS and received immediately. When the lot from BS is received, a screening process starts in order to detect the low quality items. The screening process lasts for $\frac{Q}{x}$ units of time, since the screening rate is x units per unit time. At the end of the screening process, the low quality items are sold, as a single batch, to a secondary market at a price v per unit. When the inventory level drops to s , an order up to S_1 from PS is placed. If PS is available at this time (the probability is $EP_{10}\left(\frac{(1-p)Q - Dl}{D}\right)$, where $EP_{ij}\left(\frac{(1-p)Q - Dl}{D}\right) = \int_{\alpha}^{\beta} P_{ij}\left(\frac{(1-p)Q - Dl}{D}\right) f_p(p) dp$, the lot is obtained immediately. Otherwise, a new waiting period starts during which, if PS recovers, then an order up to S_1 is obtained. If PS does not recover during the waiting period, the retailer places an order of size Q from BS at the end of it and this order is received immediately. This process is continued until either PS is available when the inventory level drops to s (type B_1) or recovers during a waiting period (type B_2).

Then, after some manipulations, the expected cycle length is equal to:

$$ET = \frac{S_1 - s}{D} + \left[\frac{1}{\mu} (e^{\mu l} - 1) + \frac{(1-m)Q}{D} - l \right] \frac{P_{01}\left(\frac{S_1 - s}{D}\right) e^{-\mu l}}{1 - e^{-\mu l} EP_{11}\left(\frac{(1-p)Q - Dl}{D}\right)}$$

and the expected total cost of the system per cycle, which is comprised of the fixed ordering cost, the holding cost, the backlogging cost and the rejection cost, is expressed as:

$$\begin{aligned}
C(S_1, s, Q, l) = & F_1 + \alpha_1(S_1 - s) + h \frac{S_1^2 - s^2}{2D} \\
& + \frac{P_{01} \left(\frac{S_1 - s}{D} \right)}{\left(1 - e^{-\mu l} EP_{11} \left(\frac{(1-p)Q - Dl}{D} \right) \right)} \left\{ h \left[\frac{s}{\mu} - \frac{D}{\mu^2} \right] (1 - e^{-\mu l}) + h \left[-sl + \frac{Dl^2}{2} + \frac{Dl}{\mu} \right] e^{-\mu l} \right. \\
& \left. - \frac{\alpha_1}{\mu} (1 - e^{-\mu l}) + \alpha_1 l e^{-\mu l} \right\} \\
& + \frac{P_{01} \left(\frac{S_1 - s}{D} \right) e^{-\mu l}}{1 - e^{-\mu l} EP_{11} \left(\frac{(1-p)Q - Dl}{D} \right)} \left\{ F_2 + a_2 Q + \frac{h(1-m)(s - Dl)Q}{D} - (1-v)mQ \right. \\
& \left. + \frac{hQ^2}{2D} [E(1-p)^2 + 2mz] \right\}
\end{aligned}$$

Using Renewal Reward Theorem, the total cost per unit time is given by: $TC(S_1, s, Q, l) = \frac{C(S_1, s, Q, l)}{ET}$

So, the objective is the minimization of the cost per unit time and it is expressed as the following nonlinear constrained optimization problem:

$$\begin{aligned}
& \min_{(S_1, s, Q, l)} TC(S_1, s, Q, l) \\
& \text{st: } S_1 \geq s, s \geq 0, Q \geq 0, 0 \leq l \leq \frac{s}{D}
\end{aligned}$$

Remark:

Counterfeit products instead of low quality could be assumed without changes in the analysis above.

Special Cases:

1. When $p \rightarrow 0$, then the model proposed by Qi, 2013, for the case with $l \leq \frac{s}{D}$, follows.
2. When $\mu \rightarrow \infty$, the classic EOQ model is obtained.

NUMERICAL EXAMPLE

Numerical analysis is conducted in order to examine the impact of imperfect quality in this mixed type strategy. For the numerical analysis, the following parameter values were used: $D = 100$; $x = 400$; $v = 10$; $\lambda = 1$; $\mu = 4$; $F_1 = 175$; $F_2 = 200$; $\alpha_1 = 2.5$; $\alpha_2 = 3$; $h = 6.5$; $p \sim U(0, \beta)$. The parameter values are similar to the values used from Qi, 2013, with the required modifications. The optimal policy and optimal cost, for different values of β are displayed in table 2.

The optimal policy for different values of β

Instance	β	S_1^*	s^*	l^*	Q^*	TC^*
1	0.5	49	0	0	180	508.86
2	0.4	47	0	0	181	484.14
3	0.3	45	0	0	180	462.15
4	0.2	44	0	0	178	442.81
5	0.1	43	0	0	175	425.94
6	0	42	0	0	171	411.31

As it is expected the cost increases as β increases. Also, the optimal policy indicates: (1) The reorder points should be zero (i.e. no safety stock is required); (2) When the second supplier is used, the waiting time l (for the PS to become available) should be zero; (3) As β increases the order quantities from both suppliers also increase.

CONCLUSIONS

In this paper, an inventory model with supply uncertainty was studied. The primary supplier is assumed to face supply disruptions, hence, after a waiting period, a backup one (more expensive) is used in order to satisfy the demand. However, the backup supplier may procure imperfect quality items. The results, through numerical analysis, showed

that, as the percentage of imperfect quality increases, the optimal policy is to increase both the order up to from the primary supplier and the order quantity from the backup one. As future research directions, partial inspection, learning in inspection or in the percentage could be assumed.

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A second order multi-class macroscopic traffic flow model with time varying parameters for environmentally sustainable coordinated ramp metering control

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Abstract

The design of motorway network-wide traffic control strategies should be optimised to address (a) environmental policies for achieving hot gas emissions targets in areas of interest (b) traffic efficiency in the sense of overall network congestion reduction and (c) equity towards all users, i.e. fair distribution of delays to all drivers using the infrastructure capacity. Addressing environmental impact explicitly in control design and not implicitly addresses needs generated by the increasing environmental concerns over vehicular traffic emissions. The fact that the environmental impact of each vehicle depends on its class (passenger cars, light vans, trucks or heavy occupancy vehicles) has led to the development of multi-class macroscopic traffic flow models that explicitly model vehicle class flow dynamics. The approach followed here is the introduction of partial densities and queues per vehicle class and the development of a mechanism for averaging the model parameters as a function of traffic class composition. Based on the developed model, optimal decisions about possible control actions can be taken. In this paper we are proposing a second order multi-class macroscopic traffic flow model with time varying model parameters. Time variability is explicitly considered by use of sigmoid curves over traffic class-composition. The result is a multi-class traffic flow model, which allows the design of MPC for various motorway traffic control measures. The problem of coordinated ramp metering is examined and an optimisation problem is formed for obtaining environmentally sustainable, efficient and equitable coordinated ramp metering strategies.

KEYWORDS: MACROSCOPIC TRAFFIC FLOW MODELS, TRAFFIC CONTROL, HOT GAS EMISSIONS, RAMP METERING, TRANSPORTATION

INTRODUCTION

Model based design of environmentally sustainable coordinated ramp metering strategies requires the development of macroscopic traffic flow models capable of describing traffic in such detail so that rapid evaluation of the environmental impact of possible control actions is feasible and relevant. Once this capability is available, optimal control problems can be formulated and solved by efficient numerical optimisation and search algorithms. In this paper we extend the well-known macroscopic second order traffic flow model METANET to its vehicle class oriented version in non-destination oriented mode. This is subsequently used for developing an optimal control problem formulation for coordinated ramp metering with the explicit consideration of vehicle hot gas emissions, allowing this way environmentally sustainable control schemes to be implemented.

THE TRAFFIC FLOW MODEL

A network of motorways is modelled as a directed graph $(\mathcal{N}, \mathcal{L})$ of nodes $n \in \mathcal{N}$ and links $\mu \in \mathcal{L}$. \mathcal{L} is divided into three subsets: \mathcal{L}_M of motorway, \mathcal{L}_O of origin and \mathcal{L}_D of destination links. Time is discretized into steps of length T_m indexed by k_m . A motorway link with l_μ lanes is divided into S_μ segments of equal length Δ_μ . Traffic conditions in segment (μ, i) are described by the vehicle density $\rho_{\mu,i}$ (veh/km/lane), space mean speed $v_{\mu,i}$ (km/h) and vehicle flow $q_{\mu,i}$ (veh/h). The dynamics of traffic for the non-destination oriented model are described by the following equations:

$$\rho_{\mu,i}(k_m+1) = \rho_{\mu,i}(k_m) + T_m (\Delta_\mu l_\mu)^{-1} [q_{\mu,i-1}(k_m) - q_{\mu,i}(k_m)] \quad (1)$$

$$v_{\mu,i}(k_m+1) = v_{\mu,i}(k_m) + T_m \sum_{\psi \in \mathcal{G}} g_{\mu,i}^{(\psi)}(k_m) \quad (2)$$

$$V[\rho_{\mu,i}(k_m)] = v_{\mu,i,\max} \exp\{-1/a_{\mu,i} [\rho_{\mu,i}(k_m) / \rho_{\mu,i,cr}]^{a_{\mu,i}}\} \quad (3)$$

$$q_{\mu,i}(k_m) = \rho_{\mu,i}(k_m) v_{\mu,i}(k_m) l_\mu \quad (4)$$

where $\rho_{\mu,i,cr}$ (veh/km/lane) the critical density and $a_{\mu,i}$ (no units) are segment specific parameters of the fundamental diagram V (km/h), $v_{\mu,i,\max}$ (km/h) the free flow speed and $\chi \in \mathcal{G} = \{relax, conv, antic, merge, drop\}$ is an index to the acceleration processes that contribute towards the total speed update in (2). Relaxation is $g_{\mu,i}^{(relax)} = [V(\rho_{\mu,i}) - v_{\mu,i}]/\tau_{\mu,i}$, convection $g_{\mu,i}^{(conv)} = v_{\mu,i} (v_{\mu,i-1} - v_{\mu,i})/\Delta_\mu$, anticipation $g_{\mu,i}^{(antic)} = v_{\mu,i} (\Delta_\mu \tau_{\mu,i} \rho_{\mu,i})^{-1} (\rho_{\mu,i} - \rho_{\mu,i+1})$, on-ramp merge $g_{\mu,i}^{(merge)} = -\delta_{\mu,i} q_o v_{\mu,1} / (\Delta_\mu l_\mu \rho_{\mu,1})$ and lane drop $g_{\mu,i}^{(drop)} = -\varphi_{\mu,i} (l_{\mu,2} - l_{\mu,1}) \rho_{\mu,1, S_{\mu,1}} v_{\mu,1}^2 (\Delta_\mu l_{\mu,1} \rho_{\mu,1,cr})^{-1}$, where $\tau_{\mu,i}$ (h), $v_{\mu,i}$ (km²/h), $\delta_{\mu,i}$ (no units), $\varphi_{\mu,i}$ (no units) are relaxation, anticipation, merging and weaving parameters, q_o in the merge term is the flow from origin o to the first segment of the downstream road link μ , and μ_1 and μ_2 are the upstream and downstream

connected links where a lane drop occurs. Traffic conditions in an origin link $o \in \mathcal{L}_O$ are described by a simple queue model, tracking the evolution of the vehicle queue length w_o (veh), which depends on the exogenous demand d_o (veh/h) generated in the environment, the downstream link's μ traffic conditions and whether or not ramp metering control measures are applied. For an origin link o , the queue dynamics are given from

$$w_o(k_m+1) = w_o(k_m) + T_m [d_o(k_m) - q_o(k_m)]. \quad (5)$$

The realised ramp flow is $q_{o,out} = r_o \min\{q_o^{(1)}, q_o^{(2)}\}$ with $q_o^{(1)} = \min\{d_o + w_o/T_m, Q_{o,max}\}$ and $q_o^{(2)} = Q_{o,max} \min\{1, (\rho_{\mu,1,max} - \rho_{\mu,1}) / (\rho_{\mu,1,max} - \rho_{\mu,1,cr})\}$, where $Q_{o,max}$ (veh/h) the maximum possible outflow from o , $\rho_{\mu,1,max}$ (veh/km/lane) the maximum density at the downstream segment and $r_o \in [0,1]$ the ramp metering rate. For a destination link $b \in \mathcal{L}_D$ the outflow $q_{b,exit}(k_m)$ (veh/h) is the flow sent to the environment, which is assumed to have infinite capacity, hence any flow calculated is pushed out of the network.

The introduction of the vehicle class (passenger cars, light or heavy trucks etc.) as a separate element allows modelling the variation in the average behaviour of traffic mirroring its composition. The single vehicle class model has a number of parameters related to the fundamental diagram (3), the speed equation (2) and the on-ramp capacity, i.e. $\rho_{\mu,i,cr}, v_{\mu,i,max}, a_{\mu,i}, \tau_{\mu,i}, \nu_{\mu,i}, \delta_{\mu,i}, \varphi_{\mu,i}, Q_{o,max}$, which are identified by a rigorous model validation procedure such as the one described in (Kotsialos *et al.*, 2002), (Poole and Kotsialos, 2016a, 2016b, 2018) based on real traffic data. The link homogeneity assumption allows the use of the same parameter value for all segments. In the multi-class case, however, the flow composition in each segment varies over time, something, which implies changes in the parameters' values at the segment level rather than at the link. Let \mathbf{p} be a suitably dimensioned vector where all model parameters are collected at the segment level, with form $\mathbf{p} = [\rho_{cr}^T, \mathbf{v}_{max}^T, \mathbf{a}^T, \boldsymbol{\tau}^T, \boldsymbol{\nu}^T, \boldsymbol{\delta}^T, \boldsymbol{\phi}^T, \mathbf{Q}_{max}^T]^T$. Its components represent averages of different characteristics and model behavioural aspects of the single vehicle class dynamic traffic flow process. The different vehicle characteristics such as maximum speed, acceleration capabilities contribute to a time-varying behaviour, i.e. \mathbf{p} is time-varying along with the evolving and changing composition of traffic.

Let \mathcal{J} be the index set of vehicle classes. The vehicle class composition rates of a motorway segment (μ,i) , $\gamma_{\mu,i,j}(k_m)$ (%) is the number of vehicles of class $j \in \mathcal{J}$ in (μ,i) at time $k_m T_m$ over the total number of vehicles in that segment at the same time; of an origin link o , $\gamma_o(k_m)$ (%) is the number of vehicles of class j over the total number of vehicles waiting in the queue $w_o(k_m)$; of the demand at an origin link o , $\vartheta_{o,j}(k_m)$ (%) is the percentage of the demand originating at o during period k_m that consists of vehicles belonging to class j . Thus, \mathbf{p} now becomes $\mathbf{p}(\boldsymbol{\gamma}(k_m))$, where $\boldsymbol{\gamma}(k_m)$ a suitably dimensioned vector of the network's compositions rates. Following the lines of previous work, (Pasquale *et al.*, 2015a, 2015b, 2017), two general vehicle classes are considered, passenger cars and trucks.

Passenger cars are divided into subclasses to account for different emissions regulations, e.g. Euro1 to Euro4, but from the perspective of traffic flow characteristics they are considered as the same class. Let $\mathcal{J}_{pac} \subset \mathcal{J}$ be the index set of the Euro passenger vehicle classes. The passenger car class composition rate $\Gamma_{\mu,i,j}$ for segment (μ,i) is $\Gamma_{\mu,i,1}(k_m) = \sum_{j \in \mathcal{J}_{pac}} \gamma_{\mu,i,j}(k_m)$ and the corresponding composition rate for trucks is $\Gamma_{\mu,i,2}(k_m) = 1 - \Gamma_{\mu,i,1}(k_m)$. A similar definition applies for the vehicle class composition rates of the origin queues and demand trajectories. Since only two vehicle classes are considered $\Gamma_{\zeta,1}(k_m) + \Gamma_{\zeta,2}(k_m) = 1$, where ζ an index containing all the location information, i.e. segment (μ,i) or origin o . Let $\boldsymbol{\Gamma}_1(k_m)$ be the vector where the composition rates are collected and $\boldsymbol{\Gamma}_2(k_m)$ the analogous vector with the trucks' composition rates. It is straightforward to change the system parameter vector dependence on $\boldsymbol{\gamma}$ to a dependence on $\boldsymbol{\Gamma}$. $\mathbf{p}[\boldsymbol{\Gamma}_1(k_m), \boldsymbol{\Gamma}_2(k_m)]$ is monotonic with respect to $\boldsymbol{\Gamma}_1(k_m)$ and $\boldsymbol{\Gamma}_2(k_m)$. A particular model parameter is bounded and varies continuously within the space $[\rho_{\zeta}^{(1)}, \rho_{\zeta}^{(2)}]$. The two bounds are the parameter's value when the traffic flow consists of only one class of vehicles. They can take either the value $\rho_{\zeta}(0,1)$ or $\rho_{\zeta}(1,0)$. Which class of vehicles corresponds to the lower and the upper limits depends on the particular parameter and its physical meaning and for each the intervals are: $[\rho_{\zeta,cr}(0,1), \rho_{\zeta,cr}(1,0)]$, $[v_{\zeta,max}(0,1), v_{\zeta,max}(1,0)]$, $[a_{\zeta}(1,0), a_{\zeta}(0,1)]$, $[\tau_{\zeta}(1,0), \tau_{\zeta}(0,1)]$, $[\nu_{\zeta}(0,1), \nu_{\zeta}(1,0)]$, $[\delta_{\zeta}(1,0), \delta_{\zeta}(0,1)]$, $[\varphi_{\zeta}(1,0), \varphi_{\zeta}(0,1)]$ and $[Q_{\zeta,max}(0,1), Q_{\zeta,max}(1,0)]$.

Contrary to approaches that consider linking two fundamental diagram parameters by a scale factor (Liu *et al.*, 2014) the parameters' dependence on traffic composition is based on the logistic curve. Let $\sigma[\Gamma_{\zeta,1}(k_m)] \in [0,1]$ be the weight function with $\sigma[\Gamma_{\zeta,1}] = \{1 + \exp[-\psi_1(\Gamma_{\zeta,1} - (\psi_2 + \rho_{\zeta}(1 - \psi_2) / (\rho_{max} l_{\mu})))]\}^{-\psi_3}$ where ψ_1, ψ_2 and ψ_3 are parameters characterising the traffic flow and ρ_{max} a global parameter. $\rho_{\zeta}(\Gamma_{\zeta,1})$ is calculated as a function of vehicle class 1 composition rate for time period from $\rho_{\zeta}(\Gamma_{\zeta,1}) = \rho_{\zeta}(1,0) \sigma[\Gamma_{\zeta,1}] + [1 - \sigma[\Gamma_{\zeta,1}]] \rho_{\zeta}(0,1)$. Parameters ψ_1, ψ_2 and ψ_3 reflect the dynamics of the model parameter change over traffic composition.

Let us define the state variable partial density per vehicle class in segment (μ,i) , as $\gamma_{\mu,i}(k_m) = \gamma_{\mu,i,j}(k_m) \rho_{\mu,i}(k_m)$. Vehicle conservation yields

$$\gamma_{\mu,i,j}(k_m+1) = \gamma_{\mu,i,j}(k_m) + T_m \Delta_{\mu}^{-1} [\gamma_{\mu,i-1,j}(k_m) v_{\mu,i-1}(k_m) - \gamma_{\mu,i,j}(k_m) v_{\mu,i}(k_m)]. \quad (6)$$

When $i=1$ eqn. (6) is adapted suitably for the node topology. If one of the upstream links is an origin o , then the term $\gamma_{\mu,i,j}(k_m) v_{\mu,i}(k_m)$ corresponding to $\mu=o$ is replaced by $\gamma_{o,j} q_o$. Let $\gamma_{o,j}$ be the partial queue per class of o defined as $\gamma_{o,j}(k_m) = \gamma_{o,j} w_o(k_m)$, which is also a state variable. Based on vehicle conservation

$$\gamma_{o,j}(k_m+1) = \{1 - q_o(k_m) / [d_o(k_m) + w_o(k_m) / T_m]\} [\gamma_{o,j}(k_m) + T_m \vartheta_{o,j}(k_m) d_o(k_m)] \quad (7)$$

and the partial outflows are given from

$$q_{o,j}(k_m) = q_o(k_m) [\vartheta_{o,j}(k_m) d_o(k_m) + \gamma_{o,j}(k_m)/T_m] / [d_o(k_m) + w_o(k_m)/T_m]. \quad (8)$$

The multi-class non-destination oriented with cross class turning rates traffic flow model consists of the equations of the single class model, the equations describing the model parameters as a function of the vehicle composition rates and the discrete time dynamic equations of the partial densities and queues.

VEHICLE EMISSIONS MODEL

The macroscopic multi-class traffic flow model described in the previous section provides the basis for calculating environmental related performance measures and more specifically hot emissions for a variety of pollutants. A suitable and well known approach is based on the COPERT emission model (Ntziachristos and Kouridis, 2007). Let \mathcal{Z} be the index set of pollutants of interest, e.g. CO , NO_x etc. and let z be the corresponding index. For a particular pollutant z and class of vehicles j the amount $\bar{\epsilon}_{j,z}(v)$ of emissions are calculated as a function of the mean speed v . $\bar{\epsilon}_{j,z}(v)$ are given analytically for different vehicle classes and fuel.

The total emissions of a particular pollutant z from vehicle class j during period k_m is

$$E_{j,z}(k_m) = T_m \{ \sum_{\mu \in \mathcal{L}_M} \sum_i \Delta_\mu l_\mu \gamma_{\mu,i,j}(k_m) \bar{\epsilon}_{j,z}[v_{\mu,i}(k_m)] + \sum_{o \in \mathcal{L}_O} \gamma_{o,j}(k_m) \bar{\epsilon}_{j,z}[v_o(k_m)] \} \quad (9)$$

where $v_o(k_m)$ is an estimate of the mean speed in origin link o . The corresponding total amount of hot emissions of z from all vehicle classes is $E_z(k_m) = \sum_{j \in \mathcal{J}} E_{j,z}(k_m)$.

An environmental policy may require stricter regulations to be applied in certain local areas and specific time intervals, e.g. near schools or hospitals. Let \mathcal{A} denote the set of special interest spatio-temporal areas. A special interest area $\mathcal{A}_\eta \in \mathcal{A}$, $\eta = 1, \dots, |\mathcal{A}|$ is a set of motorway segments and origin links outlining an area of interest and a pair of model time step indices $(k_{m,\eta 1}, k_{m,\eta 2})$, which define the time interval where stricter environmental rules are applied. First, the total amount of hot emissions of pollutant z from step $k_{m,\eta 1}$ to $k_{m,\eta 2}$ in area \mathcal{A}_η , $E_z(\mathcal{A}_\eta, k_{m,\eta 1}, k_{m,\eta 2})$ should not be larger than a maximum $E_{z,\eta, \max}$. This type of regulatory requirements yield the constraints

$$E_z(\mathcal{A}_\eta, k_{m,\eta 1}, k_{m,\eta 2}) = T_m \sum_{j \in \mathcal{J}} \sum_{k=k_{m,\eta 1}}^{k_{m,\eta 2}} \{ \sum_{(\mu,i) \in \mathcal{A}_\eta} \Delta_\mu l_\mu \gamma_{\mu,i,j}(k) \bar{\epsilon}_{j,z}[v_{\mu,i}(k)] + \sum_{o \in \mathcal{A}_\eta} \gamma_{o,j}(k) \bar{\epsilon}_{j,z}[v_o(k)] \} \leq E_{z,\eta, \max}. \quad (10)$$

Second, the amount of pollutant z emitted during any time period k_m such that $k_{m,\eta 1} \leq k_m \leq k_{m,\eta 2}$, in \mathcal{A}_η , $G_z(\mathcal{A}_\eta, k_m)$, should not exceed a predetermined threshold $G_{\mathcal{A}_\eta, z, \max}(k_m)$, yielding the constraints

$$G_z(\mathcal{A}_\eta, k_m) = T_m \{ \sum_{j \in \mathcal{J}} \{ \sum_{(\mu,i) \in \mathcal{A}_\eta} \Delta_\mu l_\mu \gamma_{\mu,i,j}(k_m) \bar{\epsilon}_{j,z}[v_{\mu,i}(k_m)] + \sum_{o \in \mathcal{A}_\eta} \gamma_{o,j}(k_m) \bar{\epsilon}_{j,z}[v_o(k_m)] \} \} \leq G_{\mathcal{A}_\eta, z, \max}(k_m). \quad (11)$$

Operational constraints (10) and (11) allow for a variety of regulations to be stated.

COORDINATED RAMP METERING FOR HOT GAS EMISSIONS OPTIMAL CONTROL PROBLEM FORMULATION

The general discrete time optimal control problem has the form

$$\min_{\mathbf{r}} \Lambda = \sum_{k_m=0}^{k_m-1} \lambda[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] + \varphi[\mathbf{x}(k_m)] \quad (12)$$

subject to

$$\mathbf{x}(k_m+1) = \mathbf{f}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] \quad (13)$$

$$\mathbf{\Pi}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] \geq \mathbf{0} \quad (14)$$

$$\mathbf{r}^{(1)} \leq \mathbf{r}(k_m) \leq \mathbf{r}^{(2)} \quad (15)$$

where \mathbf{x} is the state vector, \mathbf{r} the control vector, \mathbf{d} the disturbance vector, \mathbf{p} the model parameters vector, Λ the total cost functional, λ a stage transition cost functional, φ a final state cost, \mathbf{f} the total system model, $\mathbf{\Pi}$ a vector of problem constraints, $\mathbf{r}^{(1)}$ and $\mathbf{r}^{(2)}$ the lower and upper bounds, respectively, of the control variables. The model state vector has the form $\mathbf{x}_m^T = [\dots \rho_{\mu,i} v_{\mu,i} \gamma_{\mu,i,1} \dots \gamma_{\mu,i,|\mathcal{J}|} \dots w_o \gamma_{o,1} \dots \gamma_{o,|\mathcal{J}|} \dots]^T$. The control vector \mathbf{r} has the form $\mathbf{r}^T = [\dots r_o \dots]^T$, $o \in \mathcal{L}_O$. The disturbance vector \mathbf{d} consists of the demand and its composition at every origin link and the turning rates at every bifurcation and has the form $\mathbf{d} = [\dots d_o \vartheta_{o,1} \dots \vartheta_{o,|\mathcal{J}|} \dots \beta_{n,\mu} \dots]^T$, $o \in \mathcal{L}_O$, $n \in \mathcal{N}$. $\mathbf{\Pi}$ contains the environmental emissions constraints (10) and (11). For constraints (10), the state variables $x_{\mathcal{A}_\eta, z}(k_m)$ modelling the cumulative emissions of z in area \mathcal{A}_η until time period k_m are introduced with

$$x_{\mathcal{A}_\eta, z}(k_m+1) = \begin{cases} 0 & \text{if } k_m < k_{m,\eta 1} \\ E_z(\mathcal{A}_\eta, k_m, k_m) + x_{\mathcal{A}_\eta, z}(k_m) & \text{if } k_{m,\eta 1} \leq k_m \leq k_{m,\eta 2} \\ x_{\mathcal{A}_\eta, z}(k_m) & \text{if } k_m > k_{m,\eta 2}. \end{cases} \quad (16)$$

The cumulative emissions state variable vector $\mathbf{x}_{\mathcal{A}_\eta}^T = [\dots x_{\mathcal{A}_\eta, 1} \dots x_{\mathcal{A}_\eta, |\mathcal{Z}|} \dots]^T$, yielding the total state vector $\mathbf{x}^T = [\mathbf{x}_m^T \mathbf{x}_{\mathcal{A}_\eta}^T]^T$.

The special area emissions model $\mathbf{f}_{\mathcal{A}}$ consists of the right hand sides of the $|\mathcal{Z}| |\mathcal{A}|$ eqns. (16), which yields the total system model $\mathbf{f}^T = [\mathbf{f}_m^T \mathbf{f}_{\mathcal{A}}^T]^T$. Constraints (10) are considered in φ , which takes the form

$$\varphi[\mathbf{x}(k_m)] = \sum_{\eta=1}^{|\mathcal{A}|} \sum_{z=1}^{|\mathcal{Z}|} \max\{0, x_{\mathcal{A}_\eta, z}(k_m) - E_{z,\eta, \max}\}^2. \quad (17)$$

Parts of constraints (14) corresponding to constraints (10) are replaced by (17). Constraints (11) are implicitly considered by introducing penalty terms in the cost functional (12), given from

$$\lambda_{maxe}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = \sum_{\eta=1 \dots |\mathcal{A}|} \sum_{z=1 \dots |z|} \max\{0, G_z(\mathcal{A}_\eta, k_m) - G_{\mathcal{A}_\eta, z, \max}(k_m)\}^2. \quad (18)$$

Constraints (14) corresponding to (11) are replaced by (18) allowing constraint (14) to be dropped.

The main elements of the cost functional λ , however, are the network wide traffic efficiency, equity and hot emissions metrics. Efficiency is measured by the Total Time Spent (TTS) λ_{TTS} (veh·hours) for step k_m

$$\lambda_{TTS}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = T_m [\sum_{\mu \in \mathcal{L} \cup \mathcal{M}} \sum_i \Delta_\mu l_\mu \rho_{\mu,i}(k_m) + \sum_{o \in \mathcal{L} \cup \mathcal{O}} w_o(k_m)]. \quad (19)$$

Equity can be considered either explicitly or implicitly in the cost functional. The explicit equity expression is a measure of the variance over the on-ramps of the average time it takes a vehicle to wait in the queue to get from the origin to the motorway plus the average time it takes to travel through a representative length of motorway. Such a representative length reflects the mean travelled distance covered by a vehicle in the motorway until it leaves the network through one of the destination links. Let Δ_{eq} (km) denote this representative distance and let $\mathcal{L}_{o,eq}$ denote the set of links immediately downstream of o for which $\sum_{\mu \in \mathcal{L}_{o,eq}} \Delta_\mu \approx \Delta_{eq}$. Then, the mean travel time and queuing time for origin o during period k_m is given from $t_{o,eq}(k_m) = w_o(k_m)/q_o(k_m) + \sum_{\mu \in \mathcal{L}_{o,eq}} \sum_i \Delta_\mu / v_{\mu,i}(k_m)$ and its mean over the network on-ramps from $E[t_{o,eq}(k_m)] = \sum_{\mu \in \mathcal{L} \cup \mathcal{O}} t_{o,eq}(k_m) / |\mathcal{L}_{\mathcal{O}}|$. Equity is a measure of the variance of the mean travel times over the network's on-ramps and therefore can be explicitly included in the optimal control problem's cost functional as λ_{equi} given from

$$\lambda_{equi}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = \sum_{\mu \in \mathcal{L} \cup \mathcal{O}} [E[t_{o,eq}(k_m)] - t_{o,eq}(k_m)]^2 / |\mathcal{L}_{\mathcal{O}}|. \quad (20)$$

Equity is implicitly considered by the introduction of desired maximum queue constraints at each origin o , $w_{o,\max}$ (veh). Maximum queue constraints at an on-ramp are introduced for environmental reasons and for minimising the interference of the motorway traffic to the surrounding surface road network that may include residential areas. In order to protect such areas from increased noise and emissions from vehicles waiting in the queue, a maximum queue constraint when ramp metering is applied guides a control strategy to take action so that the ramp queues are restrained. Restraining the queue length has the effect of mitigating the necessary delays to the on-ramps upstream a bottleneck. The most efficient ramp metering actions restrain heavily the traffic entering the network from the on-ramps that are directly upstream and at a short distance from the bottleneck, whereas more equitable strategies spread the queues through the maximum queue length constraints mechanism to the upstream on-ramps at further distance away, (Kotsialos and Papageorgiou, 2004). The maximum queue length constraints are treated by introducing deviation penalty terms and their contribution to the problem's cost functional is given from

$$\lambda_{maxq}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = \sum_{\mu \in \mathcal{L} \cup \mathcal{O}} \max\{0, w_o(k_m) - w_{o,\max}\}^2. \quad (21)$$

Another operational constraint with regard to ramp metering control actions, is that generally there is a preference towards ramp metering rate trajectories which do not change rapidly in two successive control periods. A smoother flow is facilitated this way. In order to obtain control trajectories that have relatively small variance, unless it is necessary, the following penalty terms are introduced in the cost functional

$$\lambda_{rvar}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = \sum_{\mu \in \mathcal{L} \cup \mathcal{O}} [r_o(k_m-1) - r_o(k_m)]^2. \quad (22)$$

Finally, the coordinated ramp metering strategy considers the total weighted hot emissions by including the following term in the cost functional

$$\lambda_{toem}[\mathbf{x}(k_m), \mathbf{r}(k_m), \mathbf{d}(k_m); \mathbf{p}(k_m)] = \sum_{z=1 \dots |z|} \omega_{tot,z} E_z(k_m). \quad (23)$$

where $\omega_{tot,z}$ weights representing the relative importance of each pollutant.

The cost functional λ is a weighted average of contributions from (18) – (23), i.e.

$$\lambda = \lambda_{TTS} + \omega_1 \lambda_{equi} + \omega_2 \lambda_{maxq} + \omega_3 \lambda_{rvar} + \omega_4 \lambda_{toem} + \omega_5 \lambda_{maxe} \quad (24)$$

where $\omega_1, \dots, \omega_5$ are weighting parameters set manually. The resulting optimal control problem can be solved by a host of algorithms. The most efficient ones are gradient based used along with a globalisation method, such as a multistart scheme, (Kotsialos, 2019) and (Poole and Kotsialos, 2018).

CONCLUSIONS

This paper has presented a new multi-class macroscopic second order traffic flow model and an optimal control problem formulation for coordinated ramp metering. This problem formulation is capable of meeting the requirements of complex environmental policies regarding hot gas emissions on the network and on the local level. Future work will aim at further extending the traffic flow model to destination oriented description of traffic something which will pave the way for designing integrated route guidance and ramp metering model predictive controllers for implementing environmentally sustainable, efficient and equitable policies.

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Evaluating the Appropriateness of Traffic Forecasting Methods for Use in a Freight Transportation System

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Abstract

In recent decades, due to the intensification of the phenomenon of urbanization and overpopulation, more and more problems have arisen, regarding the traffic conditions, which are found daily, in every major urban network in the world. Traffic congestion has social, economic and environmental consequences, and public and private organizations have continuously tried to tackle and limit it. In this context, this paper proposes a conventional and a more alternative traffic forecasting method, which were deemed suitable for urban freight transportation problems. These methods will be utilized on an advanced vehicle routing and scheduling system that is currently under development. In order to achieve effective traffic forecasting, the scope, the time horizon, the forecasting step as well as the application challenges of forecasting algorithms need to be analyzed. Therefore, this paper includes a comparison and categorization of various traffic congestion forecasting methods. Concluding this analysis, the two most suitable methods are selected and proposed as options that would fit the implementation of the system. The first one utilizes data extracted from inductive loops and generates traffic forecasting through the ARIMA model and the second one combines data from GPS, Bluetooth and inductive loops, which it receives via a tiny traffic simulator (AIMSUN), and generates traffic forecasting through an extended Kalman filter.

KEYWORDS

Traffic Forecasting, Urban Freight Transportation, Categorization, ARIMA, Kalman Filter, Algorithms

INTRODUCTION

When dealing with traffic forecasting, it is essential to choose a forecasting method with great accuracy, based on all the collected data, regardless of the various statistical characteristics of traffic, such as non-stagnation, variability and nonlinearity (Al-Deek and Chandra, 2008). Nevertheless, the choice of the appropriate approach must be decided based on the non-stagnation and the non-linearity of the space-time evolution of traffic (Vlahogianni, Karlaftis & Golias, 2006). At the same time, the performance of the chosen method should also be taken into account. In many cases, researchers avoid evaluating their forecasting models and the errors that rise from their use. However, this is a major omission in classical statistical modeling, since sufficiently structured models are usually characterized by residual white noise (Washington, Karlaftis, and Mannering, 2010). This implies that the errors characteristics may indicate a bias, which may be attributed to missing variables or an inability to determine the functional structural form of the models. In fact, it has been found that, most artificial intelligence approaches, such as neural networks, rarely incorporate an examination of the properties of a posteriori errors. An exception is their work of Hu et al., who examined the properties of self-regulating model errors (Hu et al., 2012). Generally, it is difficult to accurately evaluate a forecasting model as it may present a good fit with the data but not accurate and reliable predictions. In any case, the designer must, on the one hand, not overlook the importance of the tests and, on the other, apply them regardless of the applied forecasting method.

COMPARISON OF TRAFFIC FORECASTING METHODS

Comparing both the parameters of each forecasting problem and the results of the application of forecasting methods is imperative, in order to evaluate their effectiveness. Karlaftis and Vlahogianni, examined effectiveness of a plethora of traffic forecasting methods and found that, in many cases, it was extremely difficult to compare these methods (Karlaftis and Vlahogianni, 2011). Kirby, Dougherty and Watson pointed out that it is highly important to accurately

perform forecasts, but also that there are other equally important parameters that need to be taken into consideration when selecting the appropriate method (Kirby, Dougherty, and Watson , 1997).

Although the choice of the "ideal" model through tests and comparisons is extremely important, a practical alternative could be the combination of models as presented in the works of (Dimitriou and Tsekeris , 2008; Sun and Zhang , 2007; Vlahogianni, Karlaftis, and Golias , 2006; Zheng, Lee, and Shi , 2006) . The positive results of the combined forecasts have been discussed in various research projects. Chrobok noted the improved forecast performance, especially for special emergencies, while Zheng presented the increased adaptability of the system when combined predictive approaches are applied (Chrobok , 2004; Zheng, Lee, and Shi , 2006).

Nevertheless, there are still issues that need to be addressed, such as identifying the following components:

- the cases where combination predictions are used.
- the most appropriate methods for combining forecasts.
- the most effective approach to combining predictions.
- the degree of error reduction, when combining predictions.

In the past years, it was sufficient to form methods with highly accurate forecasts (Yang, Yin, Liu & Ran, 2004). However, as the need to create a customized traffic forecasting system has arisen, there is an urgent need to compile algorithms, which not only accurately predict, but at the same time explain certain traffic phenomena. In other words, in addition to being sufficiently predictive, models need to be adaptable to dynamic traffic conditions and any changes in the road network environment.

Under certain conditions, linear regression, locally weighted regression, and evolutionary neural networks show satisfactory results, compared to other methods, in terms of prediction accuracy and computational effort. However, none of this has been implemented in urban networks. The ARIMA and ATHENA models, the Kalman filters, the Bayes network, the neural networks MNN, NFNN, WNN, SNN, GNN, FCNN, SSNN, TDN, CANFIS system and Kohonen self-organizing maps can also produce good results in terms of prediction accuracy. Respectively, ARIMA models, Kalman filters, Bayes networks and MNN, NFNN, WNN and TDRNN neural networks have been applied to urban networks.

Output & Input Data Type

Based on the categorization of the traffic forecasting methods, most urban traffic survey research projects adopt unilateral approaches. However, multifaceted approaches seem to have been implemented as well. Regarding the input variables, for the most part the research utilizes the traffic flow and specifically its volume. In addition, traffic flow speed, travel time and occupancy can also be used. Regarding the spatial component of input data, traffic forecasts in urban networks are applied more in points than in whole routes, larger sections of the road network or in combination. Various spatio-temporal approaches are applied to such predictions, with an emphasis on non-parametric methods and regression models (Rempe, Huber & Bogenberger, 2016).

Quality of the Data

The data, which is used in traffic load forecasts in urban arteries, comes mainly from sensors. In addition, they can also be collected by GPS systems or arise as a simulation result. Despite the reliability of data collection from sensors, such as induction loops, which is a well-documented and researched process, more advanced methods of traffic load data collection have recently emerged. Our research comes to investigate these more advanced methods and try to combine them with the existing ones. In particular, in recent years, wireless communication infrastructure and navigation technologies have redesigned the way these data are collected. Because research that incorporates new data collection technologies is still evolving, it is reasonable that the full scope of their application has not yet been evaluated. Another example is the extraction of traffic load data from social networks. Therefore, it is imperative to consider these new methods in practice. It becomes clear, that there is a great need to find methods that can make use of all the new traffic data collection technologies in order to forecast road traffic. Our research therefore, focuses on investigating such methods and aims at providing new approaches on traffic data forecasting.

SELECTION OF FORECASTING METHODS

Taking into account the above, we conclude that an overwhelming majority of different methods have been developed by researchers around the world, with the aim of predicting the traffic load. Many of them can predict traffic accurately, but still none of the methods can be considered the best method for a particular situation - in this case urban networks - let alone for all possible situations. Aiming to select the appropriate methods for traffic forecasting in urban areas, we analyzed 16 parametric and 27 non-parametric methods by collecting information from their use in previous researches and by testing their speed and accuracy.

Based on our research, the proposed methods for predicting the traffic load in assisting the development of the urban freight forwarding system are as follows:

- The first utilizes data extracted from induction loops and produces the traffic load forecast through the ARIMA model.
- In contrast, the latter combines data from GPS devices, Bluetooth as well as induction loops, which it receives via a tiny traffic simulator (AIMSUN), and generates traffic load forecasting through an extended Kalman filter. At this point, it is worth mentioning the reasons why these methods were chosen, in terms of the source of the data being processed, but also in terms of the applicable traffic load forecasting algorithm.

Selection based on the traffic load data collection method

The reason why the first algorithm was chosen, which collects data in a conventional way, although not considered the ideal way to collect data, is the proven reliability of such data, which have been collected in this way for many years. Therefore, its implementation will follow a traditional process. The reason why the second algorithm was chosen, which is undoubtedly innovative, is its promising accuracy, due to the effect of three different sources of traffic load data and in particular the "moving" data (GPS, Bluetooth). This superiority is confirmed by the fact that the combination of data from multiple sources interprets the traffic situation more efficiently, from the moment it reduces the uncertainty presented in the sources individually. In conclusion, when comparing the two methods of data collection, it becomes clear that the second proposed algorithm, is undoubtedly more effective in assessing the feasibility of routes in the context of urban freight transportation. However, its application has been limited to simulation environments, so it is not known how it will respond to real conditions, as opposed to inductive loops, the reliability of which is a given. is undoubtedly more effective in assessing the feasibility of routes in the context of urban freight. However, its application has been limited to simulation environments, so it is not known how it will respond to real conditions, as opposed to inductive loops, the reliability of which is a given.

Selection based on the applicable traffic load forecasting algorithm

At this point, it is worth commenting on the reasons why the specific approaches to traffic load forecasting were chosen. In particular, it is worth considering the reason why the extended Kalman filter with a tiny simulator is proposed primarily and the ARIMA model secondarily. As for the second algorithm, although it is based on Kalman parametric filter, it is one of the hybrid methods, due to the fact that the extensive Kalman filter applies non-parametric techniques. The choice of the extended Kalman filter arose among the following alternatives, as they are used primarily in the fusion of heterogeneous data: Neural networks, Bayes networks, vague logic models and Kalman filters.

For the selection of the Kalman filter, the aforementioned methods were initially evaluated for the speed and accuracy of their results. The evaluation showed that:

- Bayes networks are fast and produce quite accurate results.
- Vague logic models are very fast, but produce less accurate results. The accuracy of the results is a key selection criterion, so the ambiguous models were rejected.
- Neural networks show mixed results. ENNs, which are very fast and very accurate, show the best results. However, they have not yet been implemented in urban networks. The only fast and fairly accurate neural networks that have been implemented in urban networks are the MNN, NFNN, WNN and TDRNN models.
- Kalman filters are fast and produce quite accurate results.

Therefore, the choice is between Bayes networks, MNN, NFNN, WNN and TDRNN neural networks and Kalman filtering, in terms of their performance based on the degree to which the following criteria are met:

-
- Maximum efficiency. The proposed algorithm must be characterized by high accuracy regardless of uncertain or incomplete results. Bayes networks are violating this criterion, as they require a priori data, such as probability density, which cannot always be estimated within time and financial constraints. For this reason, the approach through Bayes networks was rejected.
 - Resource allocation. The application of the algorithm should minimize the use of computing resources. Although the difference in the accuracy of the results between neural networks and statistical methods, such as the Kalman filter, is not significant, the use of neural networks is time consuming and complicated to implement. As a result, neural networks were also rejected.

For the above reasons, the Kalman filter approach was chosen. The reason why the extended Kalman filter was chosen in relation to its simple version is that the simple version of the Kalman filter produces satisfactory results in linear situations, which, however, do not accurately represent the flow of traffic. In contrast, the extended Kalman filter effectively represents and non-linearly modeled situations, such as those of traffic, by linearizing them. In general, the extended Kalman filter was found to be the de facto option in traffic load forecasting using data from GPS devices.

Regarding the first parametric algorithm, for the final selection of the ARIMA model, all the methods compared in terms of their speed and accuracy, were re-evaluated. As mentioned earlier, linear regression, locally weighted regression, and evolutionary neural networks give the best results in terms of prediction accuracy and computational effort, but have not been applied to urban networks. ARIMA and ATHENA models, Kalman filtering, Bayes networks, MNN, NFNN, WNN, SNN, GNN, FCNN, SSNN, TDRNN neural networks, CANFIS system and Kohonen self-organizing maps are the most accurate. Of these methods, only ARIMA models, Kalman filtering, Bayes networks and MNN, NFNN, WNN and TDRNN neural networks have been implemented in urban networks. Comparing the latter, we observe that in general they are equal in terms of speed and accuracy. Neural networks and Bayes networks were rejected for the same reasons.

Therefore, we come up with two possible options: the ARIMA model and the Kalman filter, two parametric statistical methods. The advantage of the Kalman filter over the ARIMA model is the adaptability to its structure, as well as the satisfactory accuracy of its results even with a small set of input data. However, the literature review showed that the results of the forecasts of the ARIMA model, although having a comparable accuracy to the Kalman filter, show fewer errors. That's why the ARIMA model was chosen over the Kalman filter. we observe that in general they are equal in terms of speed and accuracy.

CONCLUSIONS

To sum up, based on our research and the categorization of the forecasting methods and their evaluation as to whether they correspond to urban networks, two traffic forecasting algorithms were proposed. The first one is a parametric algorithm, which uses the ARIMA model, which is the most standard statistical time series model in traffic prediction, with data input from inductive loops, which is the most conventional method of collecting traffic data. The second one is a hybrid algorithm that uses the extended Kalman filter, which is a variant of the traditional Kalman filter based on the Bayes filter, with data input from heterogeneous sources, namely GPS, GSM and inductive loops. Both algorithms stood out due to the accuracy of their results, while between the two, the first is distinguished for its simplicity in application and the second for greater accuracy.

Concluding our research, we would like to present some future directions on traffic load forecasting. Initially, an important step is the development of algorithms, which use real-time "on the go" data, the use of which is very promising but the related research was found to be very limited. Essential direction is also the creation of hybrid methods, which will combine the advantages of parametric and non-parametric algorithms, so as to overcome precisely or computationally the already available algorithms. Finally, conducting experimental studies, which will apply the available forecasting algorithms in different conditions, with the aim of comparing the results, is imperative. Through these studies, the infrastructure will be created, so that in the various potential problems of traffic load forecasting, it will be easier to choose the methods or the combination of the methods, depending on the respective needs.

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A Study of Digital Customer Journey through Google Trends

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Abstract

Digital Customer Journey is a process highly influenced by the offering value of commercial organizations that seek to enhance Customer Experience through Digital Transformation of their operations. The beginning of this journey usually starts with Google Search Engine utilization, the most dominant and popular search engine. Thus, key indicator for the most sought-after products and services are their respective searches online. Google Trends provides useful insights regarding online searches of specific keywords on the Google Search Engine and has been successfully utilized for research purposes in numerous scientific publications. Data that are publicly available are utilized to forecast the future demand by performing statistical analysis on the available data from previous years. Although, a rising route is expected for search terms concerning technological breakthroughs and the digital universe, what is truly important and noteworthy is the underlying hint and the information that are hidden behind raw data. It is the texture and the interpretation of this transmission that matters. Another key aspect of the current study is different locations and how they contribute to the total results when it comes to Google Trends. Geospatial data provide an added value on the Google Trends results something that Businesses evaluate before running a Search Engine Marketing (S.E.M.) campaign with Google Ads. The philosophical question that this research tackles is when and where the number of Google Trends provide added value on the topic of Customer Journey and how biased conclusions can be avoided through this exploratory research.

KEYWORDS

DIGITAL CUSTOMER JOURNEY, CUSTOMER EXPERIENCE, DIGITAL TRANSFORMATION, GOOGLE TRENDS, GOOGLE ADS,

INTRODUCTION

As a point of reference, some uncompromising and sincere factors nowadays are volume and texture of internet searches in Google platform. Internet search data may provide valuable insights into patterns of behavior. In fact, the application of Internet data in business research holds promise and may complement and extend the data foundations that presently exist. One tool that allows users to interact with Internet search data is Google Trends, a free, publicly accessible online portal of Google Inc. Google Trends analyzes a portion of the three billion daily Google Search searches and provides data on geospatial and temporal patterns in search volumes for user-specified terms.

LITERATURE REVIEW

Google Trends is an analysis tool which provides information on the monthly request frequencies of search terms that can be specified by country, time span, category, and media for the period of January 2004 to present month. Google Trends provides the total volume for requested search terms, normalized in a way that countries of different size can be compared. Normalizing takes into account the total number of search requests for each country which itself is not reported. Reported normalized scores are values between 0 and 100. For insufficient data, the value 0 is displayed. The exact algorithm used by Google Trends remains, for the most part, unknown.

Google Trends is a public web facility of Google Inc., based on Google Search, that shows how often a particular search-term is entered relative to the total search-volume across various regions of the world, and in various languages (Dinis et al. 2019). There are several reasons why Google Trends has become such a popular source for big data research and applications. First, Google Search provides an excellent platform for observing researchers' information seeking activities. It offers instant reflection of the needs, wants, demands and interests of its users. Second, Google Trends is easy to use because Google not only collects data but also provides a variety of options for comparison. Even prior to the launch of Google Trends, in fact, there had been a lot of preceding research which utilized the search information in the fields of risk management and business process management.

Studying Digital Customer Journey through exploratory research has raised awareness through the past on both research and business industry. One key aspect of data utilization through the process of visualizing the Customer

Journey is Google Trends since it enables the utilization of raising Google Search Engine terms with percentages of actual searches on this Engine (Lemon and Verhoef 2016).

Google Trends study on the car industry identifies the key aspects that drive the sales of cars in a higher number (Bauer, n.d.). Apart from the SMEs, large scale enterprises might face complex sales cycles that might hinder difficulties facing their economic demands. Research argues on the beneficial character of Machine Learning through the process of dealing with this issue (Adam 2018). Specifically, it analyses the sales forecasting according to usefulness sentimental analysis (Wijnhoven and Plant, n.d.). It is scientifically a fact that different customer segments behave in a different way from the product satisfaction, journey satisfaction, customer inspiration, and customer loyalty perspectives (Herhausen et al. 2019). Tourism has raised additional research interest regarding Trends since they can forecast the additional demand of tourists for research purposes. This brings up managerial aspects of business success concerning the Google Trends that can isolate the uprising trends even in terms of consumers interests.

From the Social Media Perspective interactions of potential customers are crucial aspects that can predict future demand or even raise the awareness of a brand which can an exploratory research such as this to give some insights on how these customers might behave in the near future (Barwitz, n.d.). A relative case of Romania indicates that the internet searches of Google Trends have lead interesting results regarding the internet community search, and conclude into results regarding the forecasting of demand in the travel industry (Popescu 2017).

New technological advances such as Virtual Reality have become game changer to the sector of Digital Customer Journey. In game industry or even in industry such as tour operators they can bring competitive advantage to the proposed services and improve Digital Customer Journey (Hollebeek et al. 2020). Regarding technology extensive researches have tackled the way it advances the customer journey regarding tourism visit experience. It seems that the prospective, active, and reflecting phase are directly influenced by technological influence support (Shen, Sotiriadis, and Zhang 2020).

METHODOLOGY AND RESEARCH IMPLEMENTATION

Google Trends Search Engine was utilized in order to extract the terms Digital Transformation, Digital Customer Engagement, Digital Customer Experience, Digital Customer Journey, Digital Customer Loyalty. The research was optimized for Worldwide results, 2004 until present time, and included all categories and Web Search results. For each of the prementioned terms the related topics indication on Google Trends was utilized in order to export the csv file with the related data. We visualized and compared all the extracted data into a single figure in order to understand the increases and decreases through the years of the prementioned searched terms. We included all the numeric data into a table in order to compare the different results and we implemented different statistical algorithms on the datasets by utilizing the SPSS program.

Figure 1: Google Trends Score Evolution of Search Terms

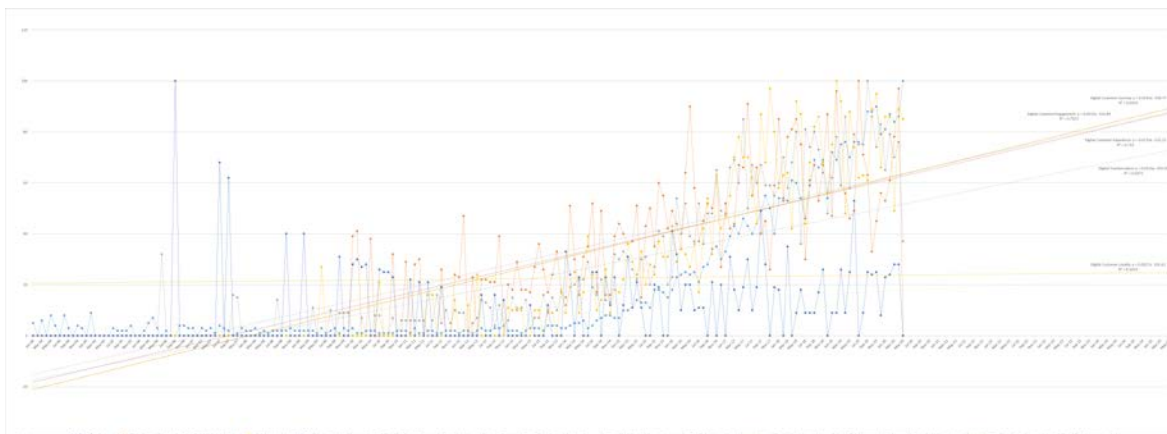


Table 1: Google Trends Linear Equations of Search Terms

Digital Transformation	$y = 0,0115x - 455,93$	R squared = 0,6071
Digital Customer Engagement	$y = 0,0132x - 516,84$	R squared = 0,7021
Digital Customer Experience	$y = 0,0135x - 532,51$	R squared = 0,743
Digital Customer Journey	$y = 0,0142x - 558,77$	R squared = 0,6933
Digital Customer Loyalty	$y = 0,0027x - 101,61$	R squared = 0,1014

Table 2: Presentation and Extension of Findings

Top Ranked Topics	Instances (Appearances)	Digital Transformation	Digital Customer Engagement	Digital Customer Experience	Digital Customer Journey	Digital Customer Loyalty	Sum	Average points per instance (appearance)
Customer	5	2	58	100	100	100	360	72.0
Customer experience	4	10	95	88	6		199	49.8
Experience	4	16	99	16	10		141	35.3
Digital transformation	4	100	12	8	4		124	31.0
Digital marketing	5	2	46	16	21	31	116	23.2
Marketing	5	2	40	18	21	33	114	22.8
Customer engagement	1	100					100	100.0
Loyalty	1	79					79	79.0
Digital data	5	6	18	22	9	17	72	14.4
Strategy	5	4	21	9	7	10	51	10.2
Management	5	3	16	8	4	8	39	7.8
Business	4	9	13	8	7		37	9.3
Company	4	3	16	5	12		36	9.0
Service	4	3	16	10	4		33	8.3
Digital media	4	16	4	4	6		30	7.5
Brand	4	6	5	4	14		29	7.3
Technology	4	4	8	6	4		22	5.5
Retail	3	5	6	10			21	7.0
Engagement	1	21					21	21.0
Loyalty program	1	21					21	21.0
Map	1	19					19	19.0
Data	3	3	11	4			18	6.0
Consumer	3	6	8	4			18	6.0
Analytics	3	8	4	6			18	6.0
Product	2	11	4				15	7.5
Customer Service	3	5	3	6			14	4.7
Cloud computing	2	2	10				12	6.0
Social media	2	8	3				11	5.5
Communication	1	11					11	11.0
Western Digital	1	10					10	10.0
Design	2	4	4				8	4.0
Advertising	1	8					8	8.0
SAP	1	8					8	8.0
Industry	2	4	3				7	3.5
McKinsey & Company	2	2	4				6	3.0
Brand loyalty	1	6					6	6.0
E-commerce	1	6					6	6.0
Organization	2	1	4				5	2.5
Convention	1	5					5	5.0
Touchpoint	1	5					5	5.0
Analysis	1	4					4	4.0
Search engine optimization	1	4					4	4.0
Software	1	4					4	4.0
Trade	1	4					4	4.0
User	1	4					4	4.0
User Experience	1	4					4	4.0
Google Analytics	1	3					3	3.0
Digitization	1	2					2	2.0
Finance	1	2					2	2.0
Information technology	1	2					2	2.0
Innovation	1	2					2	2.0
Management consulting	1	2					2	2.0
Gartner	1	1					1	1.0
LinkedIn	1	1					1	1.0
Transformation	1	1					1	1.0

Table 3: Statistics of Data Series

	Digital Transformation	Digital Customer Engagement	Digital Customer Experience	Digital Customer Journey	Digital Customer Loyalty
Mean	17.23	24.25	22.25	21.20	9.76
Std. Error of Mean	1.833	1.949	1.942	2.102	1.056
Std. Deviation	25.721	27.351	27.259	29.502	14.817
Variance	661.557	748.068	743.055	870.367	219.530
Skewness	1.599	.814	1.059	1.216	2.205
Kurtosis	1.259	-.371	-.253	.141	7.692
Sum	3395	4778	4383	4177	1923

There are different approaches and thresholds for accepted values in Skewness and Kurtosis metrics, mainly because they depend on the sample size (Ghaffari et al. 2010). Skewness measures the symmetry in data, while Kurtosis deals with the tail-heaviness of the distribution.

The best performance (closest to zero) for Skewness metric, comes from Digital Customer Engagement, which is found to be moderately skewed (between 0.5 and 1).

The best performance (closest to zero) for Kurtosis metric, comes from Digital Customer Journey.

The worst performance -as expected- in both metrics (because of the small size of the non-null observations) comes from Digital Customer Loyalty (heavily skewed (= 2.205) and leptokurtic as >3).

Table 4: Parametric Correlations of Data

Parametric Correlations (Pearson Correlation)						
	Digital Transformation	Digital Customer Engagement	Digital Customer Experience	Digital Customer Journey	Digital Customer Loyalty	Correlations Average
Digital Transformation	1	.728**	.909**	.917**	.283**	0.709
Digital Customer Engagement	.728**	1	.822**	.774**	.270**	0.648
Digital Customer Experience	.909**	.822**	1	.908**	.291**	0.732
Digital Customer Journey	.917**	.774**	.908**	1	.305**	0.726
Digital Customer Loyalty	.283**	.270**	.291**	.305**	1	0.287

** . Correlation is significant at the 0.01 level (2-tailed).

Regarding Pearson Correlation the highest correlation (.917) is observed between Digital Transformation and Digital Customer Journey, whilst the lowest correlation (.270) is observed between Digital Customer Loyalty and Digital Engagement. Furthermore, the highest average correlated variable is Digital Customer Experience (with a correlation average of .732, whilst the less average correlated variable is Digital Customer Loyalty, with a correlation average of just .287.

Table 5: Non-Parametric Correlations of Data

Non-Parametric Correlations							
		Digital Transformation	Digital Customer Engagement	Digital Customer Experience	Digital Customer Journey	Digital Customer Loyalty	Correlations Average
Digital Transformation	Kendall's tau_b Correlation Coefficient	1	.592**	.621**	.701**	.302**	0.554
Digital Customer Engagement		.592**	1	.708**	.686**	.354**	0.585
Digital Customer Experience		.621**	.708**	1	.747**	.333**	0.602
Digital Customer Journey		.701**	.686**	.747**	1	.367**	0.711
Digital Customer Loyalty		.302**	.354**	.333**	.367**	1	0.339
Digital Transformation	Spearman's rho Correlation Coefficient	1	.741**	.755**	.823**	.392**	0.677
Digital Customer Engagement		.741**	1	.853**	.816**	.446**	0.714
Digital Customer Experience		.755**	.853**	1	.872**	.433**	0.728
Digital Customer Journey		.823**	.816**	.872**	1	.458**	0.742
Digital Customer Loyalty		.392**	.446**	.433**	.458**	1	0.432

** . Correlation is significant at the 0.01 level (2-tailed).

Under Kendall's tau_b Correlation Coefficient, the highest correlation (.747) is observed between Digital Customer Experience and Digital Customer Journey, whilst the lowest correlation (.302) is observed between Digital Customer Loyalty and Digital Transformation. Furthermore, the best correlated variable is Digital Customer Journey (with a correlation average of .711, whilst the less correlated variable is Digital Customer Loyalty, with a correlation average of just .339.

The same order of results is also obtained under Spearman's rho Correlation Coefficient, with the highest correlation (.872) to be observed between Digital Customer Experience and Digital Customer Journey, whilst the lowest correlation (.392) is observed between Digital Customer Loyalty and Digital Transformation. Furthermore, the best correlated variable is Digital Customer Journey (with a correlation average of .742), whilst the less correlated variable is Digital Customer Loyalty, with a correlation average of just .432.

From the correlation analysis of the time series of our variables, a differentiation is observed between the parametric (assuming underlying statistical distributions in our data) and the non-parametric (not relying on any distribution in our data) correlations among data. This

CONCLUSIONS AND FUTURE WORK

The current research has proven the correlation between different constructs which are founded by an exploratory research based on Google Trends indicators. Different Statistical Approaches are providing different numbers of correlations, but they kept the same analogy overall between one another. The fact that this research confirms this argument, might indicate that the prementioned constructs have stable balances between them when it comes to correlation.

From a statistics point of view, it would be challenging to see a model built for the variables presented, set independent and dependent variables, perform a linear regression on the model, study the behavior of the predictors, and perform forecasting of different constructs utilized by the current research. The exploration of non-typical sources of knowledge such as Google Trends, sources that will be able to provide not just qualitative, but also quantitative data, such as preferences, behavior and changes in trend.

For non-statistical approaches researchers that seek to extract absolute values

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The adoption of cloud computing in public sector: a systematic literature review

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Abstract

Cloud computing is an innovation which radically transforms the way that information and communication technologies (ICT) are provided and is considered as a catalyst for the adoption and utilization of cutting-edge technologies that will affect every aspect of economic and social activity in the following years (IoT, Blockchain, etc.). European Commission considers cloud computing as one of the main disruptive technologies that will contribute not only to the growth of the economy but also to the digital transformation of both private and public organizations. Especially in the public sector and according to OECD, cloud computing adoption can lead to cost-savings, reduction of the total cost of ownership, high availability of information systems and services, provision of improved and enhanced capabilities to the employees, new or improved services to the citizens and more open, innovative and reliable authorities, both in central and in local government level. Therefore, public sector authorities should understand cloud computing benefits and challenges and recognize the factors that influence its adoption, in order to incorporate it into their ICT strategy and their initiatives for digital transformation in the following years. However, as stated in the literature, scientific research concerning cloud computing adoption issues is rather limited, especially in public sector and more specifically in local government. The aim of this paper is to perform a systematic literature review about cloud computing adoption in public sector. In this review, papers that study cloud computing adoption in public sector are identified, classified and analyzed, revealing theoretical-conceptual models that are applied and highlighting influencing factors that are examined through these models. The findings of our study indicate areas for future research and provide knowledge for managers and practitioners that will lead computing adoption in the public sector.

KEYWORDS

Cloud computing, ICT adoption, public sector.

INTRODUCTION

A wide number of academics and practitioners argue that cloud computing represents the emergence of a new computing paradigm (Cegielski et al., 2012; Nayak and Yassir, 2012; Vaquero et al., 2008) that is rapidly changing the conventional way IT products and services are delivered. One of the most widely used definitions about cloud computing is provided by the U.S. National Institute of Standards and Technology (Mell and Grance, 2011) which refers to cloud computing as “a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. Wang et al. (2016) consider cloud computing as the “hottest” topic in the field of information systems and argue that scientific research on the topic is going to grow in the following years, especially in areas considering adoption and impact of cloud computing.

The adoption of cloud computing offers significant advantages and can be applied to various sectors of the economy, leading to the digital transformation of private and public organizations and resulting in economic and other benefits. It is more than obvious that cloud computing is a growing market and a crucial driver for economic growth in Europe, with serious impacts for users of cloud computing services, providers and the European society as a whole (Nanos et al., 2019a). Regarding public sector, cloud computing not only has the potential to offer significant advantages, but is expected to be a fundamental part of e-government strategy in the upcoming years and lead to the digital transformation of governments at every level (central, regional, local) (Nanos et al., 2019b).

However, initiatives for cloud computing adoption in public sector are in early stage and relatively slow, comparing to initiatives for adoption in private organizations, due to various influencing-inhibiting factors (Nanos et al., 2017). Senyo et al. (2018) through a study of 285 articles, argue that more research is needed in the area of cloud computing and more specifically concerning use of theoretical models, adoption and influencing factors and focus on specific geographic or thematic areas (e.g. cloud computing adoption on specific sectors). Finally, Jones et al. (2017) argue that, as far as the local government is concerned, there is a lack of research about benefits, risks and critical success factors accompanying the decision of a local government authority to adopt cloud computing.

In order to shed light to this topic, the aim of this paper is to perform an extensive systematic literature review that will identify, code, classify and analyze existing literature about cloud computing adoption in public sector. Through this review, theoretical-conceptual models are identified, categorized, analyzed and discussed, together with influencing factors that are examined by these models.

SYSTEMATIC LITERATURE REVIEW

The systematic literature review performed in this study is based on methodologies proposed by Bandara et al. (2011) and Okoli (2015) and consists of three stages: i) research design, ii) paper selection and iii) analysis.

Research design

The aim of the research is to identify and analyze the existing literature about cloud computing adoption in public sector, in order to contribute to the scientific knowledge about the topic and constitute a basis for conducting a future empirical research.

The research questions are the following:

- ✓ RQ1: which models are used-applied for the study of cloud computing adoption in the public sector?
- ✓ RQ2: which factors that influence cloud computing adoption in the public sector are examined through these models?

For the identification of the existing literature, the following online databases were selected (in alphabetical order): ACM Digital Library, AIS Electronic Library (AISeL), Emerald Insight, ERIC Institute of Education Sciences, SAGE Journals, Science Direct, Scientific Research, Scopus, Springer, Wiley Online.

The main research criteria in the above mentioned databases were the language of the paper (English) and the existence of full-text. The search terms-keywords that were applied were:

- [Keywords : Cloud Computing] AND [abstract : Adoption]
- [Keywords : Cloud Computing OR SaaS OR IaaS OR PaaS] AND [abstract : Adoption]
- [Title : Cloud Computing] OR [Title : SaaS OR IaaS OR PaaS] AND [abstract : Adoption]
- [Keywords : Cloud Computing] AND [keywords : Adoption]

In order for a paper to be included for further analysis, the following inclusion criteria were set: i) each paper should be saved-countered only once (no duplicates), ii) the topic of the paper should be about cloud computing adoption and more specifically in the public sector, excluding papers concerning private sector, iii) the paper should propose the use of a theoretical-conceptual model and iv) the paper should include an empirical research. For the support of the research, Mendeley, MS Excel and Acrobat Reader were used.

Paper selection

The initial number of papers identified was 1,316. After the cross-checking, the deletion of duplicates and a short review of each paper abstract, the number of papers was reduced to 79. With the application of all the inclusion criteria mentioned above, the number of the papers for further study was limited to 24 (figure 1).

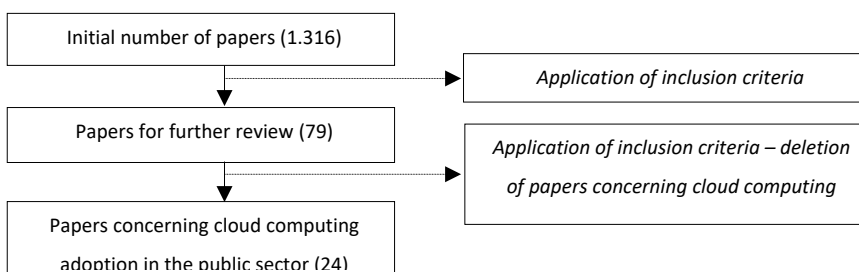
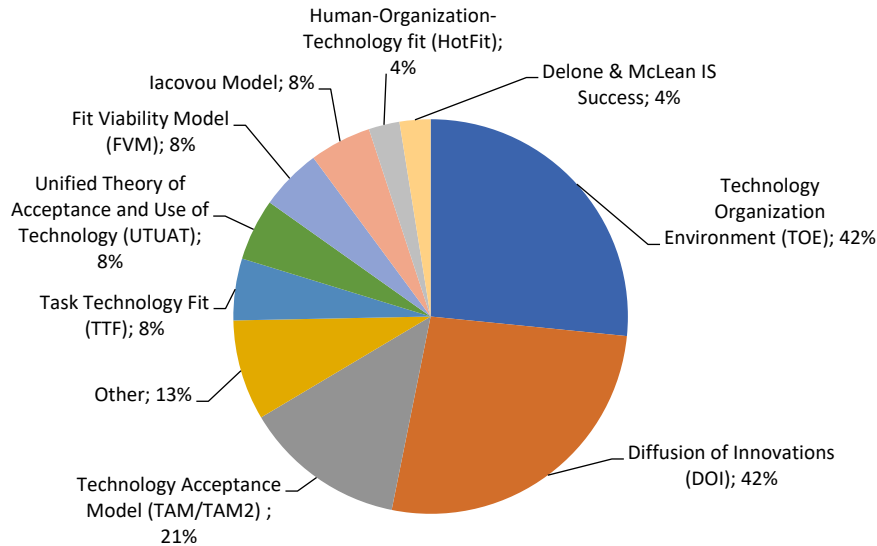


Figure 1. Paper selection through the systematic literature review

Analysis

The first step of our analysis aimed at identifying and categorizing the conceptual-theoretical models that are used for the study of cloud computing adoption in the public sector. The results show that the Technology Organization Environment (TOE) model, the Diffusion of Innovations (DOI) model and the TAM/TAM2 model are used in most of the cases.

Figure 2. Use of conceptual-theoretical models for the study of cloud computing adoption in public sector



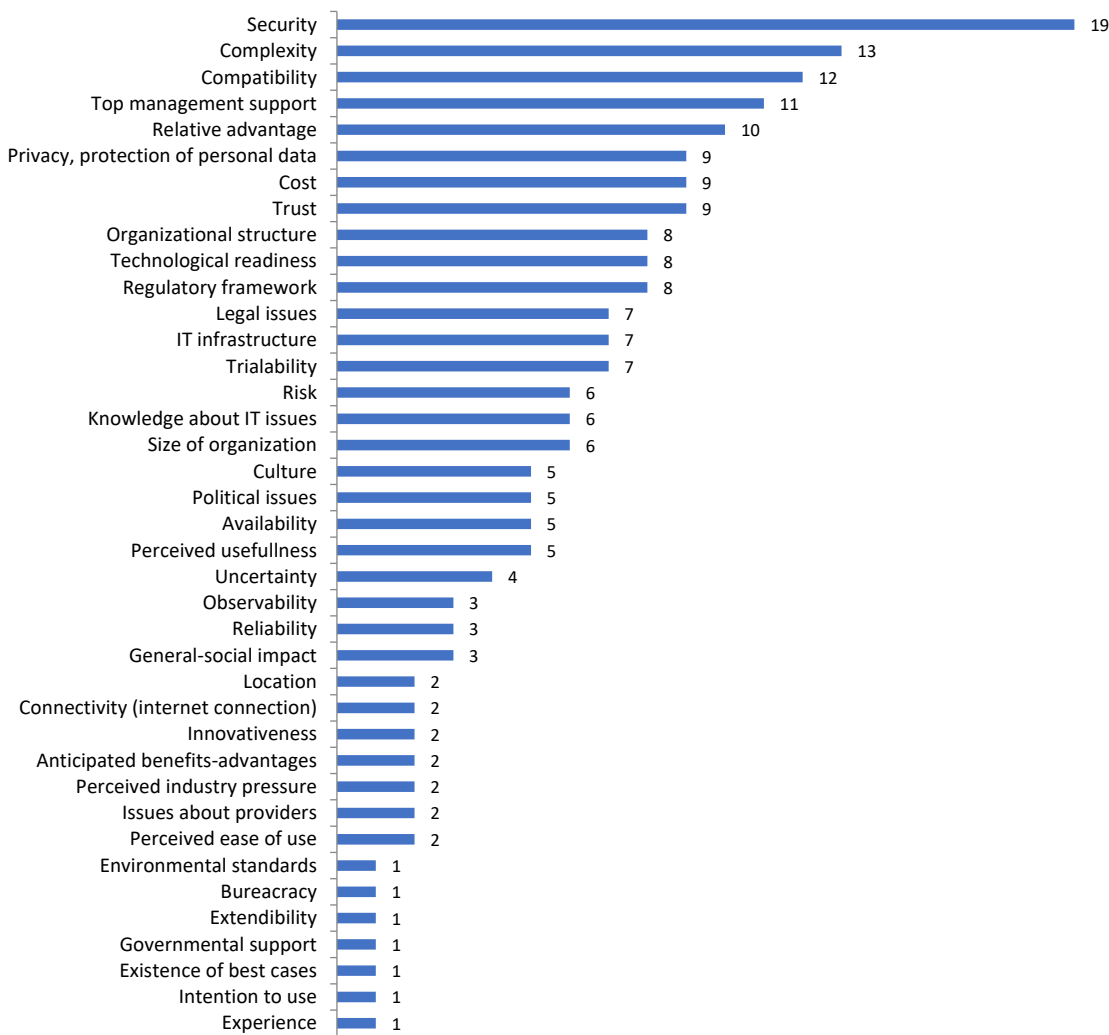
It should be noted though, that in some papers/studies only one model was used/applied, while in other papers/studies two or more models were used/applied. In the papers that used more than one model in their research, the combination of TOE and DOI was the most popular. It should be noted that the combination of TOE, DOI and TAM models was not used in any of the papers studied.

Table1 Use of conceptual-theoretical models for the study of cloud computing adoption in public sector

Model used	Number of papers/studies	Percentage
Only TOE	3	13%
Only TAM	2	8%
Only DOI	1	4%
Only UTUAT	1	4%
Other model	3	13%
Combination of models	14	58%
Sum	24	100%

The second step of our analysis aimed at identifying and categorizing the factors that influence cloud computing adoption in the public sector and are examined through the above mentioned conceptual-theoretical models. In the following figure, the identified factors are presented and classified according to the frequency (number of times) that they were used in the papers that were analyzed in our study.

Figure 3. Factors that influence cloud computing adoption in the public sector



Discussion

From the analysis of the systematic literature review, the research questions are answered as follows:

- *RQ1: which models are used-applied for the study of cloud computing adoption in the public sector?*

In the literature that was examined in our review, the conceptual-theoretical models that are mostly applied/used for the study of cloud computing adoption in public sector are the following: TOE, DOI, TAM/TAM2, TTF, UTUAT, FVM, Iacovou Model, HotFit, Delone & McLean IS Success. These models are used either alone or, in most cases, combined. When used alone, the models that are most frequently used are TOE, DOI and TAM/TAM2. When combined, at least one of TOE, DOI and TAM/TAM2 model is always used. Although these three models are widely used alone or in combination with another model, there were no papers that applied/used all the three models (TOE + DOI + TAM).

- *RQ2: which factors that influence cloud computing adoption in the public sector are examined through these models?*

As, in most cases, the study of cloud computing adoption in the public sector is examined through TOE, DOI and TAM/TAM2 models, most of the identified influencing factors are related to those models. The most widely examined factor is security issues of cloud computing applications, followed by complexity (of cloud solutions), compatibility with existing-internal applications, top management support, relative advantage (that cloud computing adoption will bring to the organization), privacy-protection of personal (employee and citizen) data, cost (of cloud solutions), trust (on cloud technology, cloud solutions and cloud service providers), organizational structure, technological readiness, regulatory framework, legal issues, IT infrastructure, trialability (ability of using cloud applications in trial version) etc.

CONCLUSIONS

Cloud computing adoption is a topic of growing interest. However, more research is needed, especially in areas like cloud computing adoption in the public sector. Empirical studies in this field will enhance scientific knowledge among academics and facilitate practitioners and managers in the decision-making process for adopting cloud solutions or migrating existing systems and applications to the cloud.

From the results of our systematic literature review about cloud computing adoption in public sector, it is evident that although most of the existing studies use/apply one or more of TOE, DOI and TAM/TAM2 models, the combined use of TOE and DOI and TAM/TAM2 models is not yet sufficiently attempted. This indicates an area that needs further exploration, since cloud computing (and ICT in general) adoption is influenced by a large number of factors that are not examined adequately by using one or even two of the above-mentioned models. Finally, our research identified, classified and presented a detailed list of influencing factors that should be examined in future academic studies through the use of an extended-combined theoretical model and taken into account from managers and practitioners that will lead computing adoption in the public sector.

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Programmatic Marketing: The Demand Side Platform in the Greek Market

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Abstract

Technological changes produced by the digital convergence are driving a paradigm shift in advertising and marketing resulting in the emergence of a new market. Programmatic Advertising plays an important role in Digital Marketing, as it manages to reflect the rapid changes in the Advertising Market, which happen due to the use of modern information technologies. Therefore, programmatic marketing is the purchasing of digital advertising space through real-time bidding, a technology that automates digital media buying. Programmatic buying and selling of digital advertising inventory, including real-time bidding (RTB) has been growing over the past couple of years and has the potential to transform how we buy and sell ad inventory.

In specific, a Demand Side Platform (DSP) is an automated buying platform, where advertisers and agencies go to purchase digital ad inventory, including banner ads on websites, native ads, mobile ads and the mobile web and video. DSPs allow advertisers and agencies to buy across a lot of sites at the same time, offering them several audience targeting capabilities, a real-time view of their campaign performance, optimizations toward a goal, and flexible budget shifting. DSPs are a part of programmatic advertising, which refers to buying digital ad space automatically.

This new advertising ecosystem includes entities with distinct roles that interact with each other, digital platforms which make ad inventory automated buying possible, and different transaction Models.

The present paper focuses on the demand side platform based on literature review and on a primary qualitative research. The chosen tool for the collection of the data was the in-depth interview. This specific tool allowed the recording and the analysis of the views, opinions, experiences and feelings of the interviewed participants about the Programmatic Marketing. Furthermore, an effort was made in order to depict the current presence of Programmatic Advertising in the Greek Market and to find out if the current situation complies with the theory or not.

Key Words: programmatic marketing, programmatic advertising, DSP platform, real-time bidding (RTB), consumer data analysis, ad inventory

INTRODUCTION

Programmatic Marketing is a new form of Digital Marketing. It encompasses multiple functions such as data collection and processing, design and implementation of digital ad campaigns, buy and sell of digital ad inventory across various devices, applications and websites. Furthermore, this new form of Digital Marketing utilizes modern information technologies so as to simplify buying and selling process and connect digitally the buyer and the seller side. Particularly, a Demand Side Platform (DSP) enables Advertisers and Agencies to buy digital ad inventory and on the other hand a Supply Side Platform (SSP) supports Publishers in selling digital ad inventory. As a result, both sides are able to enhance significantly their pricing and operational efficiency (González and Mochón, 2016). The main differences between Programmatic and Traditional media buying are the automation of the trading process and the way in which the ad message is been delivered to the consumers. Moreover, the Traditional media buying relies mainly on the human factor. On the contrary, Programmatic media buying relies mainly on the usage of software. Gradually, the levels of acceptance and trust towards Programmatic techniques are being increased among firms and marketers. In addition to this, we should underline the fact that the volume of the available ad inventory is expanding rapidly. Subsequently, more than ever before ad campaigns are being designed and implemented in terms of automation (IAB Europe, 2016a).

DEMAND SIDE PLATFORMS – THE PURCHASE OF DIGITAL INVENTORY

The Demand Side Platforms (DSP) are software systems at the disposal of Advertisers, Agencies and Firms in order for them to purchase and manage ad inventory, which are available at numerous Ad Networks, through a single interface. DSPs incorporate decision support engines and sophisticated algorithms for audience targeting and campaign optimization. The ultimate goal of a DSP is to support the aforementioned entities in buying, through a simplified procedure, those ad impressions that are suitable according to the targeted group of consumers and available through Ad Exchanges each time (Papadopoulos et al., 2017).

Going deeper into how a Demand Side Platform operates, we initially encounter the Publishers who represent the Sell Side. The primary goal of Publishers is to maximize their profits from selling their Ad inventories through digital markets such as the Ad Exchanges (IAB Europe, 2018). In simple terms, an Ad Exchange is a silo where Publishers are able to deposit their Ad inventories and make them available for the interested parties to buy (IAB Europe, 2015). Specifically, DSPs retrieve and process data which are related to consumers and originated from numerous sources such as Data Management Platforms (DMP) and Ad Exchanges. Particularly, these kind of data concern the location, the timeline, the device type and model as well as browsing preferences and behavioral patterns in relation to the Users. Subsequently, those large amounts of data transform into valuable information (IAB Europe, 2016a). Then, DSPs analyse these particular information so as to decide whether it worth's bidding each time for an Ad impression or not. In which case, if the users' profiles match the goals of the Ad campaign and the desirable group of consumers then the DSP will automatically submit its bidding offer for this particular Ad impression at the Ad Exchange (Yuan et al., 2014). Moreover, DSPs enable Advertisers and Agencies to monitor the performance of their marketing campaigns and allocate their marketing budgets in real time if it is needed. At this point, we should underline the fact that the amount of the bidding offer is defined based on CPM, CPA or CPC pricing model (Papadopoulos et al., 2017).

Demand Side Platforms are constantly evolving and enhancing their capabilities. Moreover, the criteria, based on which the categorization of a DSP is done, are continuously altering in connection to the needs of the targeted Market. However, all Demand Side Platforms do not share the same technological and operational capabilities (IAB Europe, 2015). Mistakenly, it is believed that all DSPs are capable to access the same Ad inventories. The main parameter that differentiate one DSP from another is the channel focus. There are DSPs that operate across all the available communication channels. On the other hand, there are DSPs which focuses exclusively in a single communication channel such as video supply, mobile inventory or desktop display. Therefore, Demand Side Platforms are able to support either cross channels or single channel marketing strategies and optimize the way in which Advertisers and consumers interact (IAB Europe, 2016b).

Furthermore, the selection of the suitable DSP and the appropriate supplier company is crucial for the success of the overall project. The interested parties should prioritize their selection criteria on the basis of their business goals, marketing strategy and available budget in order to find the optimal solution. The selection criteria of a DSP can be sorted in two distinct categories: economic parameters and technical specifications (IAB Europe, 2015).

Research Design and Methodology

The qualitative approach was chosen for the purposes of the current research project. The reasons which led us to this decision are: a) During the literature review, it was observed the absence of qualitative researches in the Greek literature and the limited number of corresponding researches in the foreign literature in relation to Programmatic Marketing, Demand Side Platforms and automated transaction models. b) To collect insights regarding the aforementioned research fields. c) To gain an understanding of experts' opinions, perspectives, motivations and underlying reasons. d) To uncover trends in experts' thoughts and opinions.

Respectively, the method that was adopted for data collection was In-Depth Interview. This particular qualitative research technique helped us to capture descriptive data about how the experts think and behave and unfold processes related to Programmatic Marketing. Furthermore, Thematic Analysis was chosen as the suitable method so as to analyze qualitative data and identify common themes, topics, perspectives and patterns of meaning that emerge repeatedly in the interview transcripts. At this point, we should mention the fact that the synthesis/composition of the questionnaire was held based on the findings of the literature review.

Concerning the interview process, experts from eleven different firms accepted our invitation and participated in this Qualitative research. To begin with, these firms are based in Great Britain, Holland, Germany, Greece and Israel. Secondly, all participants, regarding their educational level, are university graduates and they occupied in the following industry sectors: Marketing and Advertising, Information and Communication Technology, Data Mining and Data Analysis. The age range of the participants extends from 25 to 45 years old. The selection of the candidates who eventually composed the final sample was based on the following criteria: background knowledge, professional experience and level of expertise in the field of Programmatic Marketing. Another important criteria for the selection of a candidate, was for him or her to currently work or had previously worked either for the Advertisers (demand side) or the Publishers (sell side) or even for the both sides. By this way, we were able to compare the views and the perceptions of the participants in order to form a comprehensive overview regarding the ecosystem of Programmatic Marketing and the processes as well as the practices that it encloses. The average time of the conduction of the interviews was 70 minutes. Finally, we used NVIVO software in order to analyse the qualitative data that were gathered during the interview process.

Research Findings

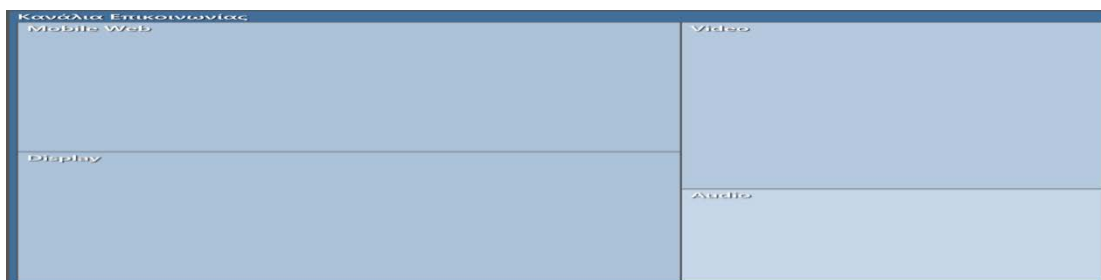
Programmatic Marketing is able to target the desirable group of customers more precisely and successfully by analyzing and reclaiming a wide range of data and information concerning them, in order to attract their interest and interact with them. The best possible understanding of customers' preferences and the most efficient communication and interaction with them, will enhance the reputation and the recognizability of the business in the Market and will bring about a substantial final profit for it.

The next step was to ask from the participants of the survey to evaluate the size of the Programmatic Marketing sector in Greece. All of them confirmed the fact that the size of the specific Market is noticeably smaller in comparison to the corresponding European Market sizes. However, it could be claimed that it shows ascending trends, as gradually more and more advertising funds are being invested on the Programmatic Advertisement. The previous findings indicate the fact that there is a potential of further development in the future.

Subsequently, we tried to find the reasons why both Greek businesses and Greek advertising agencies do not adopt the PM techniques. Through deeper analysis of the participants' opinions, it could be concluded that the main factors are the limited awareness and the lack of adequate training in Greek businesses, but also among people who are occupied with the fields of Marketing and Advertising. The hesitation from the part of Greek businesses gets more enhanced when the financial data and the amount of the available advertising funds are added to the already existing problem. We should also focus our attention on other matters, such as the adoption of the suitable philosophy and culture of all the entities which compose the ecosystem of PM in Greece.

During the efforts to find the communication channels which gain more and more popularity in the Greek Market, we concluded that Mobile Web and Display are the most popular ones. The most remarkable finding is that the demand for Mobile Web channel and Display channel is almost at the same level. The third channel in the preference list seems to be the Video, which occupies a considerable share in the Greek Market, while Audio comes fourth in the preferences according to the opinions of the survey participants. At this point, it is worth to mention that smartTV and DOOH channel are either not available as a choice in the Greek Market or there is not a remarkable demand for them.

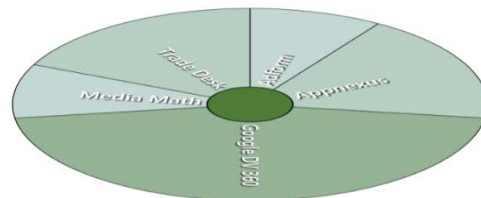
Figure 1 - Communication channels (Tree map visualization)



Afterwards, we attempted to identify what are the available platform solutions in the Market of Greece and their classification according to their popularity among the interviewed participants. It was concluded that the platform which has gained the biggest amount of popularity and is widely used by the companies occupied with the field of PM, is the Google DV 360 platform. TradeDesk and Appnexus come in the second and third place accordingly, and in the fourth and fifth place come

Adform and MediaMath platforms, according to the participants in the survey. Of course, we should not overlook the fact that a number of important companies which have developed similar software platforms, such as Amazon, Adobe or Oath, are absent from the list of the available DSP solutions. This phenomenon is possible attributed to the fact that a lot of companies which are occupied with designing and developing advertising technologies either do not hold offices in Greece, or they do not show interest in investing somehow in the Greek Market in the near future.

Figure 2 - Available DSP solutions (Sunburst visualization)



Followingly, it was identified that the main exchange models in the field of the PM in Greece are the ones of Preferred Deals και Real Time Bidding (RTB). There is also the model of Programmatic Guaranteed, which represents a smaller number of exchanges in the Greek Market. During our efforts to find the criteria according to which the interested entities choose each model instead of the others, we realized that factors such as the price, the quality of the ad inventory, ensuring the suitable ad impressions, access in data sources and long term business relationships with Publishers play an important role.

Furthermore, an effort was made to track the problems faced in the field of Programmatic Marketing and it was concluded that the actual size of the problem is quite big. The most important issue seems to be the level of transparency concerning the exchanges between the Advertisers and Publishers, as well as the individual charges. The advertising fraud is the second most significant problem in the field of the Programmatic Advertising. The third issue that is frequently met, is the matter of management and control of the data and in the fourth place, we meet the matter of brand protection.

There is also a wide controversy around the future challenges and limitations concerning PM. The answers that we recorded are about the following thematic categories: General Data Protection Regulation (GDPR), Saturation and Insecurity of the consumers, Use of Ad blocking software, Finding the specialized personnel, Brand safety, Price Levels. In conclusion, we could claim that the Programmatic Marketing field is bound to face a great number of challenges in the future. As a result, it is vital that all the involved entities cooperate and act in a coordinated way so as to be able to respond efficiently to the aforementioned challenges.

CONCLUSION

Programmatic advertising reclaims data to decide which digital advertising spaces to buy and how much to pay for them. The Programmatic Marketing promises to the advertisers the achievement of the 3-Rs, or in other words the ability to send the Right message, to the Right consumer, at the Right moment. However, these are not Programmatic Marketing only functions. Using the unprecedented possibilities offered by the Artificial Intelligence and the Machine Learning, it attempts to understand the context in which human lives evolve and analyze the complexity of the real world. Through the use of Demand Side Platforms, Advertisers and Firms are able to communicate and interact in a far more effective way with the desirable group of consumers. However, Demand Side Platforms and consequently Programmatic Marketing itself are forced to confront considerable issues such as the level of transparency concerning the exchange process and fees, the management and control of the data, brand protection and adapting to GDPR regulations. Furthermore, Programmatic Marketing is a newly established sector in Greece. As a result, the conduct of a qualitative research which focuses in a such recently formed sector, is expected to face challenges towards its course of completion. For instance, the number of firms and individuals that are active in this particular sector and the level of expertise and experience that the executives possess.

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Growth hacking marketing strategies in the early stages of start-ups

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Abstract

Marketing is a critical business operation for the growth, success, and sustainability of start-ups. However, young entrepreneurs with innovative ideas face significant challenges in trying to reach consumers. Particularly in the early stages of establishing and operating a start-up company, limited capital resources and difficulties accessing various sources of funding hinder the ability to design and develop integrated advertising campaigns. The lack of efficient marketing processes leads to high failure rates of start-up companies and entrepreneurs focus on finding smarter and low-cost strategies to boost their sales. Growth hacking is an experiment-driven technique to determine the most effective ways of growing a business. In order to reach out to a massive audience, entrepreneurs need to adopt different growth hacking techniques. Although some amongst these techniques have only been around for a few years, nonetheless, they prove to play a vital role in the growth of modern-day businesses. The process involves a mix of marketing, development, design, engineering, data, and analytics. This paper presents a literature review on entrepreneurial marketing techniques that implement new technologies and identifies smarter and inexpensive alternatives to traditional marketing that can boost start-up sales, such as content and viral marketing.

KEYWORDS

Entrepreneurial marketing, Growth hacking, Digital Marketing, Start-ups, Online Promotion

INTRODUCTION

Marketing is an important challenge for contemporary innovative businesses, playing a pivotal part in their development and viability, given their limited recognizability and capacity to equally compete with businesses already established in the market (O'Dwyer et al., 2009). Furthermore, the use of current low cost technological and digital means, is necessary due to the increasing cost of traditional advertising as well as due to an overall realization that these established means, such as the television, lack effectiveness, particularly regarding attracting younger age group demographics (Keller & Fay, 2012).

It was already made clear since the 1990s that start-ups need to develop some more sophisticated marketing techniques compared to established companies in order to become competitive and sustainable. Within this context, the term 'entrepreneurial marketing' was highlighted, referring to marketing small sized businesses based on non-linear procedures for the purpose of effectively promoting innovative products and services (Bjerke & Hultman, 2004). Entrepreneurial marketing is an organizational function that reflects an overall process of creativity, communication and value proposition to customers for the purpose of effectively managing customer relations in such ways that benefit both the business and the individual parties involved (Kraus et al 2010). This practice is defined by innovation, risk taking and proactivity, while it can be implemented by utilizing limited financial resources (Lewrick et al, 2011).

Therefore, new entrepreneurs with innovative ideas face challenges from the initial stages of start-up development in their effort to verify the product/market fit to approach their consumer audience receiving useful feedback from their initial customers (Giardino et al., 2014), which is a crucial process for the development of their business within the lean startup development model. The lean startup model is a model that favours experimenting strategic programming (Ries, 2011). Many start-ups, especially, do not develop according to established methods and many successful businesses historically went through the stage of failing multiple times, but improved their original idea through ongoing interaction with their customers. The lean start-up method prefers experimentation regarding careful programming, customer reviews regarding intuition as well as repeated design besides traditional development techniques. This new model radically changes start-up design, as it highlights the feedback value by the customer audience (Blank, 2013) with the purpose of creating the Minimum Viable Product (MVP) whose success determines the subsequent course and financing potential by venture capitals (Moogk, 2012). In summary, according to the lean startup development model there is no sole strategy that needs to be followed but rather a plethora of ongoing trials until the most appropriate plan is identified. Similarly, in line with the digital era, digital marketing techniques are the basic channel of implementing

entrepreneurial marketing in the sense that they contribute to reinforcing corporate branding, accessing a wide consumer audience and creating customer fidelity. Within this context, growth hacking was recently introduced as a term, which is a combination of creative marketing, analyzing data and developing, ultimately aiming towards fast tracked development. Growth hacking is an experimental process around different electronic marketing channels, with the ultimate aim of growing and attracting a consumer audience and is based on fast programming and the lean start-up model (Bohnsack & Liesner, 2019). Growth hacking uses measurable indicators as part of its methodology, in order to implement easy, economical but also effective internet marketing techniques (Lee, 2016). Growth hackers are marketer experts, knowledgeable around computer science programming and combine creativity with data analysis (Geru et al., 2014).

GROWTH HACKING FOR START-UPS

Considering this perspective, several marketing techniques have been highlighted for start-ups who lack sufficient funds for mass advertising through traditional communication means, implementing the inbound marketing methodology in order to convert stranger to promoter by following the process of 1) attract, 2) connect, 3) engage (Hubspot, 2006). Inbound marketing is mainly implemented through content marketing which subsequently is largely implemented through digital means such as blogs, microsites, newsletters, electronic magazines, websites and social media. Growth hackers focus on creating, distributing and managing valuable, relevant and reliable content for the purpose of attracting and maintaining a clearly designated audience towards the ultimate goal of achieving profiting and profitable customer relations (Basney, 2014). Marketing is a highly popular added value strategy for innovative businesses, which is based on interaction, accessibility to useful information, speed and content-user interaction, essentially bearing minimum marginal cost for companies per potential individual user (Koiso-Kanttila, 2004). This content is usually distributed between the corporate website and social media. Even though growth hacking techniques are not common for each individual start-up as they differ in terms of their target audience, product or service, there are tactics that can be factored based on their individual differences (Lee, 2016).

Webpages

Having a website is a requirement for content marketing. Creating a website that is the main channel of communication for the start-up with its prospective customers can be done through the use of open source content management systems. Therefore the desired outcome can be accomplished within a shorter period of time and thus, lower cost (Shivalingaiah & Naik, 2009).

Coming soon pages

A common practice used by start-ups is to create coming-soon or pre-launch websites in order to collect user data. They offer something in return as they intend to engage users in order to receive some useful feedback regarding the project under development. Often visitors register their email address to get access to the early phases of the project. A typical example is the 2004 Gmail service that was initially accessible only to users who were invited to access their limited data release, for the purpose of testing the service within a limited audience and to make the necessary adjustments (McCracken, 2014). These initial users could then in turn invite a certain number of third-party users and thus operate as promoters.

Keyword research and competition analysis

A pivotal tactic is identifying keywords used by users in search engines. This is done through studying statistical data and competition analysis in order to record the key words targeted by direct competitors. At the same time long-tail keywords which are searched for in high volume are identified and are considered niche with lower competition levels (Saura et al., 2019). Some keyword research and analysis tools are: Google Ads Keyword Planner, AnswerThePublic, Ubersuggest, Moz Keyword Explorer.

Search Engine Optimization

Search Engine Optimization (SEO) refers to all the processes that are linked to creating website structure and content in order to achieve the highest possible ranking in search engines and therefore, increase how often a website is visited by online users through organic results, namely non-sponsored advertisements (Dou et al, 2010). However, implementing appropriate interventions in a website is not an easy task, as it has been argued that over 200 factors affect its ranking in Google's search engine (O'Neill & Curran, 2011). These factors are classed as either on-page or off-

page factors. Amongst these, some pivotal factors which impact on website classification in search engine result pages are website keywords, SSL, the website being mobile responsive, text to code ratio, quality and quantity of backlinks etc. (Ziakis et al., 2019). Furthermore, website SEO for start-ups that aim towards the global market is a pivotal variable in terms of their effectiveness, particularly with regards to the localization factor, namely their ability to adapt their products/services based on different consumer needs (Thoumrungrroje & Rose, 2005). Finally, it is crucial to optimize each landing page of the website in terms of a key phrase. Some monitoring tools that are useful regarding SEO for a website are: Google Webmasters Search Console, WooRank, SeoSiteCheckup, Sitechecker, GrowthBar.

Website Analytics

Website analytics are extremely useful for data monitoring around website traffic, generating statistical data and forming datasets into diagrams accordingly, reports and depictions that enable their interpretation as well as making adjustments and improvements (Farney, 2011). Google analytics is the most well known tool amongst these, which enables the user to generate statistical data regarding website visitors and website traffic, such as the number of individual visits, views, visit duration and bounce rates (Vlachopoulou, 2020). Website administrators are able to identify website conversion rates through online traffic statistics analysis. In line with this, website administrators are able to get more detailed data regarding user behavior and conversion rates through also using Google Tag Manager as a tool for this. Low conversion rates should flag up as an issue for website administrators who ought to then implement conversion optimization practices in order to improve website effectiveness. Other tools such as Hotjar interactively portray user activity and interaction with the website.

Conversion Rate Optimization

A/B Testing

The A/B split testing method is a way of monitoring changes that are linked to designing a website, in order to determine which of these changes optimize its conversion rate. This technique involves testing two or more website versions, to ascertain which of these is the most efficient (Siroker & Koomen, 2013). Certain implementation tools of this technique are: Google Optimize, Omniconvert, Optimizely, VWO

Landing Page optimization

The overall aim of a destination website is to convert its visitors into sales or prospective customers (Gafni, 2018). It is highlighted that there are easily visible call to action buttons in landing pages or forms that can be used by website visitors to communicate, to interact with the website for this to be registered as a conversion (Ash et al., 2012). The optimization process of website landing pages includes techniques such as incorporating visible call to action buttons. If a user does not engage in interaction, a last resort would be an exit-intend pop-up encouraging the user to remain on the website by offering, for instance, a certain discount or useful content in the form of an e-book by signing up for its newsletter. Statistics analysis can confirm various implementation scenarios for landing pages and to increase conversion rates by converting a lost visitor to a potential prospective buyer. Some known tools for creating effective landing pages are: LeadPages, InstaPage, Unbounce, Landingi.

E-mail & CRM integrations

Collecting contact details for prospective customer contact in the future is a financial tactic used by many start-ups as it has been proven that effective use of email marketing can result in high conversion rates. In order to make optimal use of this technique, it is necessary to effectively interconnect landing pages with CRM systems (Petru et al., 2019); Mailchimp and Sumo are popular tools in the hands of growth hackers.

Social Media & Third-party services

Social media as well as third party pages through the Google Display Network are another crucial channel for promoting the content developed by a start-up in order to promote its products or its services. Social media such as Facebook, Youtube, LinkedIn, Instagram, Twitter etc provide significant advantages for start-ups, which face limitations regarding financial resources, time as well as expertise on marketing (Chitra & Sasikala, 2016).

The following section of this paper presents growth hacking techniques related to social media and third-party websites.

Viral Marketing

Viral marketing is about the use of social media, with the purpose of sharing the content that a company chooses to communicate fast, gaining customer fidelity and reinforcing corporate branding (Phelps et al, 2004). Viral marketing aims to create positive views about a company and its products/services from the perspective of its potential customers, while saving in terms of financial and human resources (Curtis et al, 2010). Glean is a viral marketing tool which enables users to take part in online contests as promoters for advertising content.

Remarketing techniques

Remarketing techniques as a term refers to marketing techniques used by businesses to reintroduce their products or services to current or prospective customers; it can be implemented through various channels. This process focuses on utilizing technology for retargeting previous website visitors and is a very effective technique with high conversion rates (Yang et al., 2015). To be more specific, through this technique advertisement content may pop up to a user that previously visited a website but did not proceed to a conversion. A way to implement this is through Facebook Pixel as well as Google Ads, where a user that visited the website but did not proceed to a conversion can then view targeted advertisement content during a future navigation in third party websites such as Facebook or websites that are part of Google Display Network.

Marketing workflow automation

Marketing automation is an automated and unifying process in terms of marketing activities which enables contemporary businesses to individualize communication messages, to effectively approach users and to support prospective customers (Heimbach et al., 2015). It contributes to increasing productivity without requiring additional financial or human resources. In order for growth hackers to conduct complex data analysis through different online sources, solutions which unify information from various external services have been developed. Zapier and Automate.io are such solutions which contribute to workflow automation for different social media. Furthermore, services such as Hootsuite connect accounts among different social media platforms and offer start-uppers the option to time social media posts while analyzing the effectiveness of these activities. At the same time, tools such as chatbots can be incorporated both in websites and in social media, enabling start-ups to provide personalized support to their potential customers through automated means, thus drastically reducing cost related to hiring staff while providing users with support options 24/7. Landbot and MobileMonkey are some known tools for creating chatbots.

CONCLUSIONS

It is clear that start-ups need to develop some more sophisticated marketing techniques compared to established companies to become competitive and sustainable. Even though there isn't a sole recommended communication strategy for start-ups as these differ depending on their target audience, product or service, most of these utilize the Internet as well as digital technology means in order to contain their operational cost, to ensure and reform provided solutions by identifying their initial customers as well as reinforcing branding, which in turn contributes to getting funding thus reinforcing their success rates. This paper attempted to identify growth hacking techniques and available tools which can be utilized by both start-ups and by businesses endeavoring to operate online through adopting an e-business model related to inbound marketing. It is worth noting that, given that the aforementioned techniques are based on a rationale focusing on data analysis and processing, start-uppers operating outside of the European Union ought to seriously consider any potential limitations that may ensue due to General Data Protection Regulation (GDPR) and therefore readjust their terms and conditions of use.

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Session 7: Decision Support Systems

chair: Nikolaos Spanoudakis

Development of a web-based multi-criteria decision support system for benchmarking

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Abstract

The possibility to compare alternatives is a useful tool and provides useful information to decision-makers in businesses and organizations. Such features with many applications were proposed and included in the MARKEX system. The current demands of the market and decision makers, as well as the new possibilities and developments in technology and research, have forced the expansion of capabilities and the development of a new web-based decision support system.

In this work, a web-based decision support system for market analysis and simulation is presented, which implements the MARKEX methodology. The aim is to study consumer behavior, market segmentation and competition analysis.

The system has been developed and operates as an educational tool and has the potential to add new research efforts. Its databases are based on data from special market research. The system's model base so far includes the multi-criteria method UTASTAR, the Negotiable Alternatives Identifier (NAI) algorithm, and brand choice models. The system works in a web environment and has been developed in python and javascript languages. The presentation of the system will be through its application in market research data for extra virgin olive oil products in the French market.

KEYWORDS:

Multi-Criteria Decision Analysis, Decision Support Systems, Benchmarking, Marketing, Python

INTRODUCTION

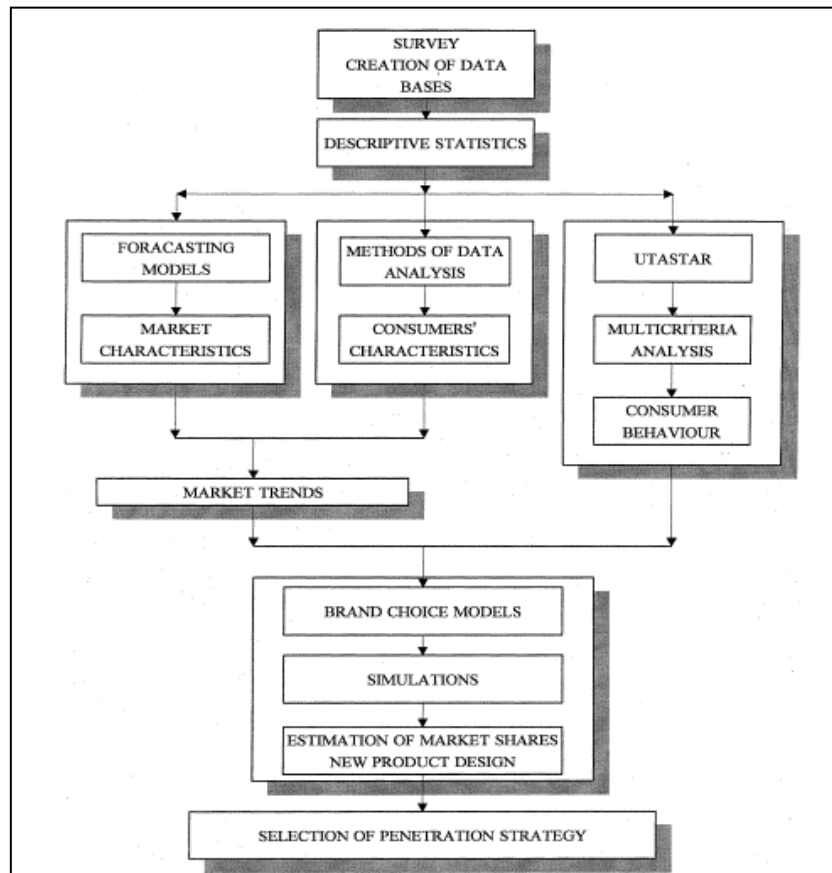
Marketers all over the world, who work at any small or larger business, always have to face the problem of deciding what strategies to follow, in order to develop new products or upgrade the current ones. Possible goals of these strategies are the successful launch of a new product, the entry of a current product in a new market and the assurance or the improvement of the existing market share of the existing products. Taking all these into consideration, choosing the most suitable strategy for every purpose, plays a crucial role to the profitability of a business and as a result, to the sustainability and the development of an enterprise or the bankruptcy of it. Taking the advantage of the extensive capabilities of programming languages like python and javascript, and the versatility of python frameworks, like Django, we are going to present a special marketing decision support tool that will change the way that marketing decisions are made, decreasing the possible, already referred, risks.

MARKEKX

The Markex methodology (Matsatsinis and Siskos, 1999; 2003), accepts as input data from market research, with which we gather consumer preferences on a set of alternatives (products). Based on these data, a multi-criteria table is created for each consumer (decision-maker) which includes the evaluations of each alternative (product) on a set of criteria as well as the global preferences in the form of ranking of alternatives (Figure 1: MARKEX flow chart). Then, Utastar (Siskos & Yannacopoulos, 1985; Siskos et al., 2016) is applied to each multi-criteria table, from which we obtain for each consumer, the weights of the criteria (importance), the marginal and global utilities of each alternative.

Subsequently, by implementing consumer brand choice models on the Utastar-exported products utilities, Markex(Matsatsinis & Samaras, 2000) calculates market shares and gives the ability of market simulation based on alternative market scenarios.

Figure 1: MARKEK flow chart (Matsatsinis & Siskos, 1999)

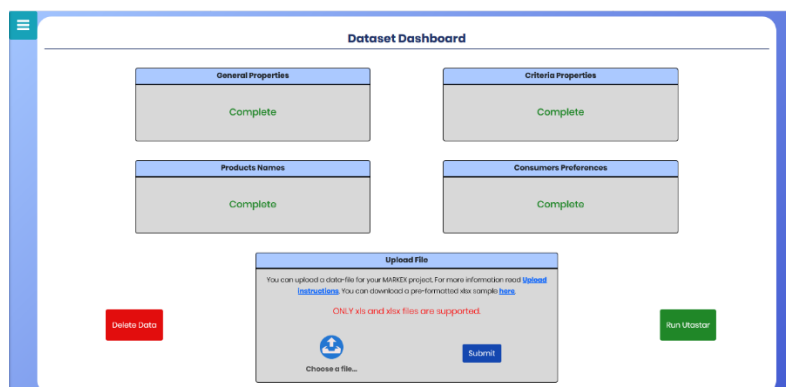


SYSTEM

Data

The survey data from consumers can be inserted in the system either via an online form or by uploading a specially formatted xlsx file (Figure 2, Survey submission page). Furthermore, an extra option of creating a dataset using a generator has been installed for educational purposes. The dataset in this example has been taken from a survey for olive oil in the French market (Baourakis, G., N.F. Matsatsinis and Y. Siskos, 1996).

Figure 2: Survey submission page



Results

Using the results from Utastar method, the system can perform the following functions. On the clustering page, decision maker is able to create consumers clusters based on the consumers' preferences, according to his personal preferences, by choosing the significance and the significance level for every criterion, using the special menu (Figure 3: Cluster creation menu). Moreover, by implementing the algorithm NAI (Negotiative Alternative Identifier) (Yen J., 1999), the system can calculate the product which works as the compromising solution between all consumers.

Figure 3: Cluster creation menu

Consumers Clustering based on Criteria Significance Combinations							
Criterion	Average Weight	Significance Level	Role in Cluster			Consumers Number	Consumers Percentage
Influence	0.161	<input type="text" value="0.161"/>	Significant	Non Significant	Indifferent	Average Weights: 61	Average Weights: 29.90%
Color	0.134	<input type="text" value="0.122"/>	Significant	Non Significant	Indifferent		
Odour	0.135	<input type="text" value="0.135"/>	Significant	Non Significant	Indifferent		
Taste	0.166	<input type="text" value="0.316"/>	Significant	Non Significant	Indifferent		
Packaging	0.188	<input type="text" value="0.142"/>	Significant	Non Significant	Indifferent		
Price	0.237	<input type="text" value="0.244"/>	Significant	Non Significant	Indifferent		
						Maximum Weights: 8	Maximum Weights: 3.92%

In the single scenarios tab, decision maker can change the values in the multicriteria table (Figure 4, Multicriteria table) and in the same time he can add or remove products and calculate the new market shares, using all the available consumer brand selection models (Matsatsinis & Siskos, 1999).

Figure 4: Multicriteria Table

<input checked="" type="checkbox"/>	Product	Influence Level	Color Level	Odour Level	Taste Level	Packaging Level	Price Level	
<input checked="" type="checkbox"/>	CARAPPELLI	<input type="text" value="3"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="3"/>	<input type="text" value="31"/>	<input type="button" value="🗑"/>
<input checked="" type="checkbox"/>	LERIDA	<input type="text" value="3"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="3"/>	<input type="text" value="65"/>	<input type="button" value="🗑"/>
<input checked="" type="checkbox"/>	KOLYMVARI	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="20"/>	<input type="button" value="🗑"/>
<input checked="" type="checkbox"/>	HEDIARD	<input type="text" value="3"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="3"/>	<input type="text" value="48"/>	<input type="button" value="🗑"/>
<input checked="" type="checkbox"/>	JARRE_dOR	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="37"/>	<input type="button" value="🗑"/>
<input checked="" type="checkbox"/>	PUGET	<input type="text" value="3"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="2"/>	<input type="text" value="3"/>	<input type="text" value="18"/>	<input type="button" value="🗑"/>

Figure 5: Single scenarios tab



Taking the product LERIDA, has been chosen a simulation for the combinations of the criteria Color and Price, within [1,2] by step 1 and [30,60] by step 15, respectively. So, for the values {1,2} and {30,45,60}, respectively. As a result, the following combinations (Color, Price) occur (1,30), (1,45), (1,60), (2,30), (2,45), (2,60) and based on these, the market shares for every combination are calculated. The results are displayed in (Figure 6, multiple scenarios page).

Figure 6: Multiple scenarios tab



CONCLUSIONS

In conclusion, the developed system gives to the marketing decision makers the ability to estimate the market shares of the products for all the possible scenarios in a web-based and user-friendly environment. As a result, it makes the decision of launching a new product much easier than before and reduces the possible risks. Moreover, the current system has the ability to be extended by adding a large number of possible subsystems, which can support the decision maker during more steps of the product development. These additions, can lead to an integrated solution of supporting the launching of a new product and to a new era for the marketing-oriented decision support systems.

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Financing Sustainable Energy Efficiency Projects: The Role of Stakeholders

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Abstract

Energy efficiency finance is considered of utmost importance for the achievement of the European Union's (EU) energy and climate objectives for 2030 and beyond. However, it remains a challenge how to identify which investments could foster sustainable growth, while also having the capacity to meet their commitments from the first stages of investments generation. In the meanwhile, stakeholder engagement is becoming an important component aiming to enlighten the gap of all policy and decision support processes. The aim of this study is to develop a concrete methodological approach that aims at involving highly relevant stakeholders, gathering their input and/ or training them in terms of energy efficiency financing. The key actors are identified among all the relevant stakeholder groups, while their roles, interest, motives and power are analysed. The main challenge to be addressed towards this direction is how to ensure the necessary consultation with financial institutional bodies and market operators at national and EU level, which is fundamental for achieving a successful finance of energy efficiency projects. Finally, the study could serve as an analytical guide on the development of a stakeholder engagement plan that could effectively exploit the broad scope of the financial instruments and various experiences of the market actors including their required knowledge and skills towards the energy efficiency investments financing.

KEYWORDS

Energy and Climate Policy, Energy Efficiency Investment, Decision Support, Stakeholder Engagement.

INTRODUCTION

Mainstreaming Energy Efficiency (EE) finance is considered as a key priority to avert climate change **Invalid source specified..** The European Commission (EC) has set EE as one of its main pillars, in order to reduce greenhouse gas (GHG) emissions and increase energy security **Invalid source specified..** Although EC launched in January 2015 the Investment Plan for Europe as the main tool to kick start sustainable growth, EE is not yet considered as an attractive investment by the financial sector. As a result, innovative decision support schemes and standardisation tools for respective key actors are required in order to boost EE investments.

The shift towards EE investments to foster sustainable growth is unlikely to occur without a high level of stakeholder engagement in the decision support processes and policy development. It is, therefore, vitally important to identify a stakeholder engagement strategy, in order to fill in the gap on the development phase of EE investments, where plenty of EE project ideas exist, but they often tend to never be financed.

The lack of expertise and knowledge, the different perspective of investors and bankers, the absence of EE-based criteria for project financing, make the EE financing unattractive business for many financial institutions. The involvement of stakeholders is key to ensure that the outcomes are immediately exploitable by a large number of interested institutions **Invalid source specified.Invalid source specified..**

Stakeholder engagement is considered a tool to manage human interactions in a manner that yields benefits to the stakeholders and enhances the outcomes of the activity they are involved in (Lehtinen J. & Aaltonen K., 2020) . A well-prepared stakeholder engagement plan is a prerequisite for the successful financing of sustainable EE projects (Garard J. &Kowarsch M., 2017)**Invalid source specified..**

Their role could result in better implementation of EE projects' financing through:

- managing the complex nature of the EE investments that is characterised by heterogeneity;

- assisting regulators in tailoring policies built on a better understanding of stakeholders' role, interest and goals;
- developing strategies and tools to increase the interest and the influence of interested stakeholders in EE;
- quantifying and comparing the influences of stakeholders on the decisions regarding adapting innovative sustainable ways to finance EE projects.

This paper proposes a concrete methodological approach aiming at involving highly relevant stakeholders from a variety of sectors, gathering their input and training them in terms of EE financing.

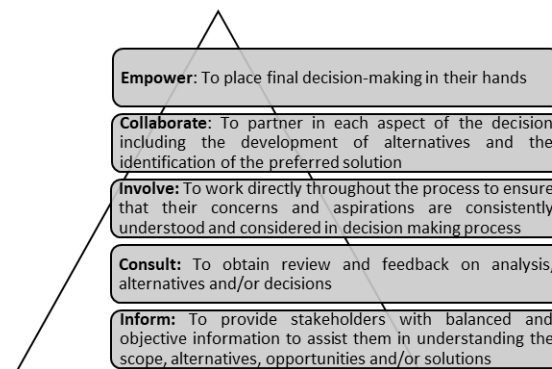
Apart from this introductory section, the rest of the paper is structured as follows: Section 2 identifies the role of stakeholder engagement in EE financing, Section 3 presents a 3-step methodological approach for a concrete stakeholder engagement strategy, Section 4 outlines the impact analysis of stakeholders' role in EE financing and, finally, Section 5 summarizes the main conclusions and proposals for further research.

THE ROLE OF STAKEHOLDER ENGAGEMENT IN ENERGY EFFICIENCY FINANCING

A science- based stakeholder dialogue could be considered a well-designed structured communicative procedure of linking scientists with selected key actors with the knowledge, expertise and insights particularly relevant for the scientific process (Höfer T. & Madlener R., 2020) (Karakosta C. & Papapostolou A., 2020).

Dialogue with stakeholders could be purely informative, therefore not requiring a very active involvement of external participants in the research process, or, on the contrary, seek to develop a full participatory process **Invalid source specified. Invalid source specified..** In this case, stakeholders collaborate in every aspect of the decision-making process and jointly participate in the finalisation of outcomes. An overview of the different levels of stakeholders' participation is given in Figure 1.

Figure 1: Different levels of stakeholders participation (Karakosta C. & Papapostolou A., 2020)



The identification of targeted stakeholders and the early engagement of key actors are crucial for the successful identification of attractive EE project ideas at an early stage of investments conceptualization **Invalid source specified..**

The purpose of a well-established stakeholder engagement that could boost the EE financing procedure focuses on:

- mobilizing data and information collection and process regarding sustainable financing of EE projects;
- coordination and facilitation of activities to be in line with laws regarding EE;
- synthesizing the needs, requirements and aspirations towards sustainability of EE financing;
- information providing to key actors about the targets of the actions planned.

The level of stakeholder participation in the process of EE financing is differentiated depending on their power and interest. It varies from minimal effort when necessary to constantly participation in the decision-making processes and relevant activities as key players. Their interaction and involvement increase proportionally with their power and interest.

The main objective of all the engagement levels is to attract relevant stakeholders, so that they are familiar with EE financing, ideally by participating in technical development phases, events, policy frameworks and eventually become active users of the derived outcomes.

To ensure effectiveness, it is important not only to identify all the relevant target groups, but also to understand what type of effort and messages should be used.

METHODOLOGICAL APPROACH

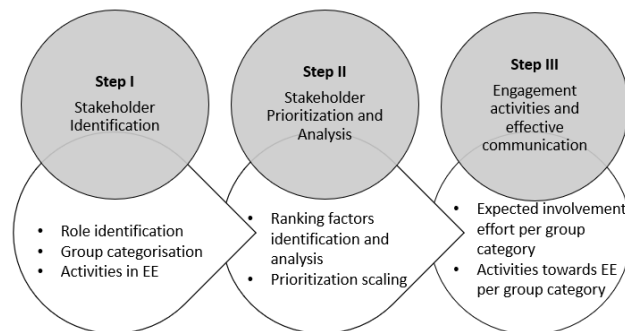
In this section, a 3-step methodological approach is presented as a concrete stakeholder engagement plan to ensure successful financing of EE projects (Figure 2).

Step I: Stakeholders Identification

In order to successfully identify and finance attractive EE project ideas, relevant key actors should be addressed and engaged. In this step, a list of relevant groups is compiled. The identification procedure contains basic information about the entity, its role and short description of activities relevant to the topic, range of energy EE activities (experience with various types of EE projects – financing schemes, technologies, etc.).

In this way, a balanced professional, institutional and geographical representation of stakeholders will be ensured. A proposed categorization of stakeholders’ groups for sustainable EE financing is the following: (A) Investors, (B) Project developers, (C) Policy makers, (D) Research and Academia, (E) Other bodies.

Figure 2: 3-step methodological approach for stakeholder engagement



Step II: Stakeholders Prioritization and Analysis

Ranking stakeholders’ relevance, according to their expertise, interest, power, influence, commitment, and interest levels, will help to target and engage each stakeholder properly. The identified stakeholders should be assessed regarding their assumed power to influence regulatory frameworks and/or financial flows for energy efficiency projects, and regarding their assumed interest in outcomes.

Within the three categories (power, interest, overall importance) stakeholders are ranked along the scale “Low”, “Medium”, “High”. The three levels of power and interest are assigned, and their combination determines the overall importance (Table 1).

Table 1: Stakeholders prioritization scale

Power / Interest	Low	Medium	High
Low	III.	III.	II.
Medium	III.	II.	I.
High	II.	I.	I.

Step III: Engagement activities and effective communication

To ensure the effectiveness of EE financing, it is important not only to identify all the relevant target groups, but also to understand what type of effort and messages should be used each target group.

Well-defined participatory activities should be proposed including specific and concrete actions and to be established for the identified stakeholders, in order to foster their contribution (Table 2).

Table 2: Stakeholders activities towards sustainable EE financing

Activity	Description	Target Groups
Bilateral and multilateral consultation	Telephone calls, skype, physical meetings, interviews, questionnaire	A, B & C
Regional training workshops	Dynamic dialogue at targeted workshops to train regional/ national stakeholders and address their specific needs.	A, B & C
Standardised tools and benchmarks	Computerized decision support tools and guidelines Knowledge database to integrate and illustrate results of status quo analysis	A, B & C

Lessons learnt and policy recommendations	A sketch of policy frameworks and market architecture with recommendations for countries and EU level.	A, B & C
Dissemination activities to raise awareness	Newsletters, press releases, social media, articles, infographics, informative material.	A, B, C, D & E

IMPACT ANALYSIS OF STAKEHOLDERS' ROLE IN ENERGY EFFICIENCY FINANCING

The proposed methodological approach for stakeholder engagement could justify several needs and achieve different goals towards mainstreaming EE financing.

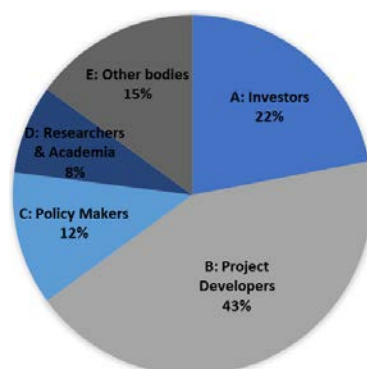
Within the European H2020 project "Triple-A: Enhancing at an Early Stage the Investment Value Chain of Energy Efficiency Projects", a result-oriented approach is presented, seeking to identify which investments could be considered as Triple-A investments, fostering sustainable growth, while having an extremely strong capacity to meet their commitments, already from the first stages of investments generation and preselection / pre-evaluation (Triple-A, 2019).

Based on the proposed methodology, an intense stakeholder dialogue and consultation process is taken place in order to ensure the effective engagement of stakeholders which are considered as crucial for the project's outcomes and their sustainability.

Up to date, 443 stakeholders have been identified and prioritised (Figure 3) according to the proposed methodology. An overview of the up to date stakeholder consultation activities that have been conducted across different key target groups within several EU countries is the following:

- **Questionnaire for identification and validation of risk factors:** Project categories and beneficiaries in EE investments and evaluation criteria are being validated by experts and professionals identified within Step I of stakeholder engagement plan. In this context, a questionnaire has been distributed and feedback is being gathered.
- **Consultation for testing the Triple-A Tools:** Publicly available standardized Triple-A tools and benchmarks to effectively assess sustainable EE investments are being tested and reviewed by the identified stakeholders. This action has the potential to ensure the use of Triple-A outcomes by these stakeholders, as they will have participated actively in the formulation of the tools.
- **Organisation of and participation in training workshops/webinars/conferences:** Targeted events are being organised, in order to raise awareness, further disseminate project outcomes and encourage stakeholders' participation in the exploitation of the project outcomes.

Figure 3: Stakeholders categories taken into consideration in the context of Triple-A project



CONCLUSIONS

The proposed plan provides a useful tool for the identification of the key actors in the field of EE financing, the prioritization according their needs and their engagement through targeted consultation activities.

The benefits of this active participatory approach are the clearer identification of the existing gaps in the policy and decision support processes, the raising of awareness and the overcoming of conflicts and streamlining implementation of sustainable EE finance. Thus, this approach assists in reducing the uncertainty of investors, project developers, policy makers and other relevant stakeholders and help better understand the complexity of the EE investments not only in regional level but in EU level as well.

The outcome of this approach and the strong involvement of all relevant stakeholders could be a fine-tailored policy package, offering a concise representation of key outcomes, guidelines for practical implementation and cooperation actions reflecting market needs.

ACKNOWLEDGEMENT

The current paper is based on the research conducted with the framework of the EU Horizon 2020 project “Triple-A: Enhancing at an Early Stage the Investment Value Chain of Energy Efficiency Projects” (grant 846569, <https://aaa-h2020.eu>). The contents of the paper are the sole responsibility of its authors and do not necessarily reflect the views of the EC.

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Decision Support Tool for Ranking Robotic Process Automation Candidate projects

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Abstract

Our work in this paper is firstly about discovering the criteria required for a successful Robotic Process Automation (RPA) project proposal assessment aiming to raise the chances for a successful implementation. Robotic Process Automation is a modern field of Information Technology allowing organizations to automate mundane and mechanically repeated human tasks. Secondly, this research provides a tool to assess potential processes for automation effectively. The literature reviewed for this study is previous research of RPA as well as successful case studies. The theoretical part of the study was completed by interviewing six experts in the field. The result of this work is the creation of a tool that assists organisations with the selection, assessment, and prioritisation of processes for automation. After discovering the criteria we asked two experts to prioritize sample projects (many of them real-life proposals) and used the UTA* method for extracting the weights in order to develop a decision support tool. The research suggests that it is crucial to conduct a process assessment before development since many RPA projects fail due to poor choice of processes. The results suggest that there are ten main criteria when evaluating a process for RPA and three criteria, which, in combination with some of the main criteria, have an impact on the prioritisation. The Process Assessment Model is a simple but effective tool for organisations to quickly remove processes that are not ideal for automation with RPA. The Process Assessment Formula is a tool which calculates the complexity of the process as well as the value it will provide, if automated, to decide whether the process should be automated and categorize it in a priority table. Our tool can assist organisations in deciding effectively which processes can be automated, and which are suitable for automation.

KEYWORDS

Multiple-Criteria Decision Analysis, Robotic Process Automation, Decision Support Systems

INTRODUCTION

The origin of Robotic Process Automation (RPA) can be found back in the 1990s when screen scraping software was introduced. Since then, RPA quietly evolved until 2015, when it became mainstream. Today, new RPA software is released regularly with [Automation Anywhere](#), [Blue Prism](#), and [UiPath](#) being the leaders in the market. RPA, as defined by IRPAAI (Institute for Robotic Process Automation & Artificial Intelligence), is the application of technology that allows to configure computer software to capture and interpret existing applications for processing a transaction, manipulating data, triggering responses, and communicating with other applications or systems, as a robot would do if given strict instructions. We are not talking about robotics, but software robots that automate work by imitating tasks executed by humans. As the robots are made to behave just like a human would, RPA is often referred as a non-invasive technology and therefore there is no need to change anything on the software that RPA is interacting with.

With the assistance of RPA technologies, the use systems that are difficult to integrate can now be automated. RPA can provide multiple benefits if used correctly, e.g., free valuable time from staff, decrease operational costs, reduce the cost of consumables by forcing digitisation, raise staff satisfaction, provide faster processing times, reduce errors and create more reliable analyses. While all this sounds promising, RPA comes with some risks, like every automation technology. RPA helps complete routine tasks faster and at a higher quality, but it can also make mistakes faster. Insufficient definition of business rules and poor data quality can result in never achieving the benefits RPA can offer. Furthermore, RPA can be seen as a threat to the labour market as employees working on tasks that can be automated could face job loss.

An inaccurate assessment of the processes could lead to increased development costs that could also result in the termination of a project. A study conducted by Ernst & Young (Ernst & Young, 2016) says that as many as 30% to 50% of initial RPA projects fail due to poor choice of process. Thus, it is crucial to conduct a process assessment before development. Wrongly defined assessment criteria might lead to selecting a process for automation that might not be a good match for RPA.

In our work, we conducted six interviews that discuss different parts of the RPA process evaluation and that assisted us in finding the criteria that should be considered when evaluating a process for RPA. With the use of the *coding* method (Sharp, 2018), the most important criteria were discovered and, with the use of UTA* (Siskos & Yannacopoulos, 1985), the weights of the criteria were determined and used in the Process Assessment Formula tool. We developed two tools: a) the **Process Assessment Model**, which is a simple flow with both technical and business-related criteria the project and the process must satisfy to move to the next phase, and, b) the **Process Assessment Formula (PAF)**, which is a tool developed in Excel that allows the user to evaluate a candidate process's performance on each of the selected criteria and then get the value each process is expected to provide, and its complexity.

In the following we first provide an overview of the criteria elicitation process (section 2) and then we present the tools that we developed (section 3). Section 4 concludes.

CRITERIA ELICITATION METHODOLOGY

The method used in this research is qualitative and the followed process is based on the proposal of Kothari (2004). The research begins by defining the research problem; in our case this was done by talking to experts in the field and by examining the available literature (case studies). The data collected through interviews and unstructured questionnaires was then analysed through *Coding*. Coding is an analytical process, where data is categorised to facilitate analysis (Sharp, 2018). Our criteria assessment was completed based on the analysed data and on the comparison to our findings based on our literature review. To get results from a qualitative analysis, a step-by-step process must be followed (Löfgren, 2013). First, the researcher reads the transcripts and takes notes. After that, relevant information is labelled. Labels can be for any concept the researcher thinks are relevant to the research. Then, the researcher decides which codes are the most important and creates categories by combining several codes. In this step, many of the initial codes can be dropped since more essential and relevant codes are created. The categories are labelled, and the researcher can now decide which are the most relevant and how they are connected. Finally, before writing the results, the researcher can decide if there is a hierarchy among the categories and draw a figure to summarise the results.

In the following paragraphs we outline the literature review and the findings from the interviews. For more information the interested reader can consult the thesis of Batakis (2020).

We selected three case study reports, one for each of the most successful RPA tools (i.e. [Automation Anywhere](#), [Blue Prism](#), and [UiPath](#)) aiming to find the different key criteria that each company uses to select the processes to automate as well as the benefits acquired from the success of their RPA implementation. All three papers are part of a research project conducted by Lacity, Willcocks, and Craig (2015). We found that automating processes that are suitable candidates deliver benefits such as:

- Full Time Equivalent (FTE) employee labour time saving, i.e. cost reduction
- Reduced errors, improved service quality
- Increased Staff satisfaction, FTE redeployment, focus on more critical tasks
- Return of Investment (ROI) in a few months or a multiple in a few years
- Re-investment in RPA, scale RPA team, increase the number of processes automated

To try to automate a process that is not a right candidate will not only get someone further away from those benefits but can also be a negative experience that will push a company away from RPA. From the case studies, we derived the following characteristics of suitable candidate processes for automation:

- Highly manual and repetitive processes (i.e. running frequently and involve much manual work)
- Rule-based processes where decision making is based on standardised and predictive rules)
- Stable and mature processes (i.e. that are stable, predictable, and mature)
- High volume processes (with high transaction volumes)
- Processes whose input is in a standard electronic format, not reliant to Optical Character Recognition (OCR) technologies (e.g. emails or Excel/Word/PDF files)
- No human intervention will be required after automation (removing human intervention reduces errors and the time required to complete the process)

After the literature review we proceeded to the interviews. Four categories were developed during the coding of the interviews: a) RPA and Automation, b) Business Goals and RPA Benefits, c) Project and Process Issues, d) Process Selection and Process Characteristics.

By analyzing the replies of the interviewees, the following criteria were derived: a) multiple FTEs can be saved, b) high volume of transactions, c) highly manual process, d) low number of exceptions, e) low to zero human intervention after the application, f) no change expected in the near future, g) no human judgement involved, h) reliant to one individual, i) repetitive, j) rules-based decision making, k) systems the robot interacts with are stable with no disconnects, glitches or crashes, l) standard electronic input, m) structured data involved, n) process uses multiple

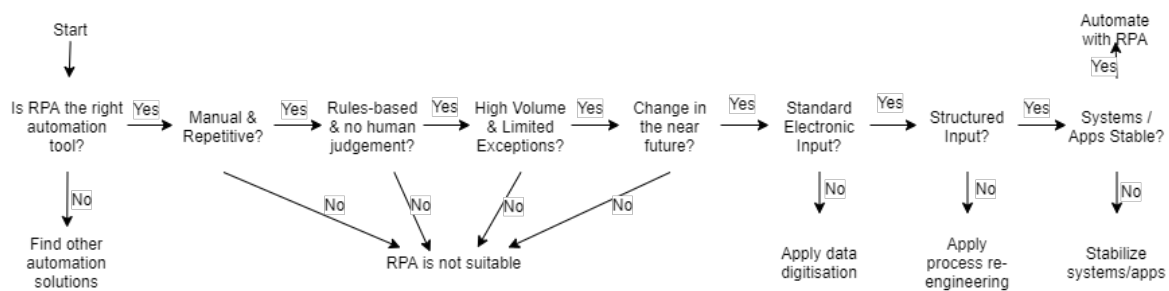
systems/applications, o) time saved is greater than the time required to automate the process, p) time-consuming task. Some of these criteria are not conclusive, and some play a more significant role in the decision of whether the process can be automated or not.

PROCESS AND TOOLS

Multiple business and technical criteria should be used to evaluate whether a process is suitable for RPA, and, after that, whether it is a promising candidate. Two mechanisms were created to assist an organisation in determining whether a process is suitable for automation: Firstly, the Process Assessment Model, a simplified flow, which determines if a process can be automated. Secondly, the Process Assessment Formula, which determines whether a process is suitable for automation and assists organisations with prioritising suitable processes.

The Process Assessment Model was created based on the ten main criteria that were derived from the interviews and the research made on RPA and the case studies.

Figure 1. Process Assessment Model



The Process Assessment Formula (PAF) is a tool which can determine whether a process is automatable and then prioritise all the processes added. The PAF has been created in Excel. After the process selection criteria were identified, the criteria that influence the Value and the Complexity were derived with the assistance of Interviewees 3 and 6. The next step was to calculate the weights of the criteria with the use of UTA* (Siskos and Yannacopoulos, 1985).

The UTA methods refer to the philosophy of assessing a set of value or utility functions, assuming the axiomatic basis of multiattribute utility theory and adopting the preference disaggregation principle (Siskos et al., 2016). The UTA* methodology uses linear programming techniques in order to optimally infer additive value/utility functions so that these functions are as consistent as possible with the global decision-maker's preferences (inference principle).

The next step was to define the UTA* multicriteria problem. For UTA* to provide the weights for the criteria that influence the Value and Complexity of each interviewer four tables with numerical values were created for each interviewer, one for Value and one for Complexity. In Table the reader can see the first five lines of the Multi-criteria Matrix for calculating the weights of the criteria influencing the Value the process can provide if automated. The following criteria are used (qualitative/quantitative, worst value, best value):

VCR1: No. of FTEs Volume, the volume of the process counted in FTEs (quantitative, 0.1, 10)

VCR2: Possibility (in percentage format) of the process changing in the near future (quantitative, 33, 0)

VCR3: Reliant to one individual, being reliant to more than one individual brings risk (qualitative, 0, 1)

VCR4: Time Consuming, whether the process requires a lot of human working effort (qualitative, 0, 1)

VCR5: Strategic Importance, a business might want a process automated even though it is not the best candidate, e.g. the business wants to reduce the number of human errors currently made (qualitative, 0, 1)

VCR6: Number of Systems the robot is interacting with (quantitative, 1, 10)

After the tables were filled, UTA* was run on Matlab for each set to derive the weights taken on Value and Complexity by the processes of Interviewee 3 and afterwards of Interviewee 6. In Table the weights of the two interviewees (I1 and I2) are shown for the six criteria in the first two rows, while the third row shows the average weights. The mean value of the weights on each criteria was taken and then used in the Processes Assessment Formula. As seen on Table 2 below, VCR1 (no. of FTEs) is the most important criterion when calculating the Value the process provides. As an interviewee suggested, 2 FTEs can be considered a financial break-even threshold if the headcount is removed, however, headcount reduction is usually only possible when over 5 FTEs are working the process. That means that an organization will receive the best ROI when the number of FTEs is high.

Table 1. Multi-criteria Matrix for calculating the weights of the criteria for Value (first five rows)

alt/cri	VCR1	VCR2	VCR3	VCR4	VCR5	VCR6	Ranking
J1	5	0	0	0	1	5	1
J2	6	15	0	1	0	2	2
J3	2	0	0	1	1	5	2
J4	1	0	1	1	1	3	2
J5	6	20	0	1	0	2	3

Table 2. The criteria weights for Value for both decision makers (dm) and their average values

dm/cri	VCR1	VCR2	VCR3	VCR4	VCR5	VCR6
I1	0.446	0.189	0.085	0.117	0.108	0.055
I2	0.367	0.161	0.173	0.063	0.160	0.077
Average	0.406	0.175	0.129	0.090	0.134	0.066

Exactly the same process took place for the Complexity computation and ranking of the projects. In this case, we had five criteria, i.e. (qualitative/quantitative, worst value, best value, average weight):

CCR1: Number of systems the robot is interacting with (quantitative, 10, 1, 0.142)

CCR2: Standard Electronic Input, input received is in an electronic format (qualitative, 2, 0, 0.108)

CCR3: Structured Input, the data received are in a predictable form or table (qualitative, 0, 1, 0.123)

CCR4: % of Exceptions, % of the process that is not following the happy path (quantitative, 33, 0, 0.099)

CCR5: No. of steps the robot requires to complete the process, each click is considered a step (quantitative, 100, 5, 0.527)

Notice that here there is a criterion, i.e. CCR5, that is by far the most important. The other four are all around 0.1, however CCR5 is more than 0.5. Multiple interviewees stated that the number of steps plays an important role in the complexity of a process being automated which also results in more time required for development. More steps in a process means more work for the development team, higher possibility for mistakes in the process documents as well as higher number of exception paths that need to be developed

To summarise, in order for the Process Assessment Formula tool to provide results, the user fills the necessary cells, Excel makes calculations in the background based on the weights obtained by UTA* and the calculations created on Excel for each criteria. Finally, the tool provides information on whether the process can be automated and its Complexity, Value and Priority (see Table 3).

Table 3. Priority Table: First priority have processes that have low complexity (<30%) and high value (>60%), see number 1 in the top-right cell. Second are those processes that have low complexity and average value (30-60%), etc.

Complexity	Low (<30%)	5	2	1
	Med (>=30%)	7	4	3
	High (>=60%)	9	8	6
		Low (<30%)	Med (>=30%)	High (>=60%)
		Value		

CONCLUSIONS

Robotic Process Automation tools are software robots that are used on information systems to complete tasks the same way as humans. There are more than 30 different RPA tools in the market which when used correctly, can help an organisation achieve multiple benefits such as cost savings, raise of staff and customer satisfaction, and error reduction. The three different case studies were examined, analysed, and the following characteristics were determined as essential for a process to be considered for automation with RPA: A process should be highly manual and repetitive, rules-based, stable, have high volume, and be provided standard electronic input. By conducting interviews with six experts in the field of RPA it was determined that organisations use RPA technology to provide efficiency. Furthermore, it was found that a process should be highly manual and repetitive, have high process volumes, be rules-based, have standard electronic inputs and should have structured data, a low number of exceptions, should not change radically in the near future, and should not require human judgement.

To conclude, RPA tools, when used correctly, can provide multiple benefits to an organisation. However, as many as 50% of initial RPA projects fail due to poor choice of process. For an organisation to implement its projects successfully, a thorough evaluation of each of the processes for automation must be done. This procedure can be done either by

following the criteria found during the interviews or by using the Process Assessment tools created by the work presented in this paper.

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Session 8:
Multiple Criteria Decision Analysis
chair: Georgios Aretoulis

Multi Criteria Evolutionary Algorithm for Research Team Formation

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Abstract

Considering that research teams are the structural social unit of science, research team formation is one of the key operations in collaborative learning and research. Due to the NP-hard nature of the problem we introduce a new mechanism based on an evolutionary and decision-making algorithm approach for attaining the optimal or nearly optimal team for a specific project, satisfying the constraints of the project. One of the main features of the proposed method is that it allows for the consideration of as many constraints as may be required, by helping to find the best solution through the multiple-choice process of limited alternatives, translating the team problem into one of decision-making optimization problem. In order to verify our approach, an experiment was designed and tested with two case studies forming teams from a pool of 3000 virtual researchers, considering specific constraints. Results of the experiment allowed for the validation, not only from the computational point of view by measuring the algorithmic performance, but also to detect the issues to be considered for the improvement of the algorithm.

KEYWORDS

Multi-Criteria, Evolutionary Algorithms, PROMETHEE, Team Forming, MCDA

INTRODUCTION

Until recently, science has experienced large scale changes at all levels: institutional, intellectual, and social, as well as in its relationship with society. In order to correspond to the changes, the science community has adopted a problem-driven approach to knowledge production, leading to multi/inter/trans disciplinarily approaches (Baber et al., 1995). Many universities and IT organizations are shifting away from individual work to team work environment, because it can reduce individuals' workload and also can be used to support a variety of functions for an organization. Even though team formation may sound quite simple, it is actually a very complex problem, because it doesn't depend only on how many characteristics, skills or criteria considered or weighted but also in many other reasons like forming algorithms, techniques etc. Still in such case, a simple method may easily find a satisfactory solution/s, but high skills peer members aren't the only requirement for adequate team work (Liu and Tsai, 2008). Many studies produce good results (Stavrou et al., 2018), but many of them focus in limited characteristics or have other limitations which effect team members or the performance of the team (Jin et al., 2020), (Baghel and Bhavani, 2018; Gutiérrez et al., 2016). The purpose of our research focuses on finding the best solution among the best alternatives by overcoming other studies limitations, evaluating not only the skills/characteristics of the team members but also by calculating the performance score of each team member. In Section 2 we identify the problem furthermore in Section 3 we analyze the approach and present the model of team formation using an evolutionary and decision-making algorithm and Section 4 includes all our case studies and scenarios that were tested, and finally our conclusions and re-marks for future work.

PROBLEM IDENTIFICATION

This paper investigates a multi criteria evolutionary algorithm approach for project team formation considering competency of candidates and overall team skill performance for specific projects with specific criteria. Many approaches have been implemented to solve team formation problems most of which have specific constraints as mentioned above [3]. Due to limitation and performance issues in applying only PROMETHEE method in large solution spaces, a prototype algorithm that combines evolutionary and Multi-Criteria Decision Analysis (MCDA) algorithm was developed. Our approach tries to overcome performance and limitations of other implementations, and, if needed, add specific constraints from the project administrator (ex. includes specific researchers to the team).

The problem of research team formation involves the distribution of different researchers with various skillsets to a specific project that usually requires more than an area of expertise while optimizing other specific criteria. For this problem we consider:

- a number of researchers R , $R = \{R_1, R_2, R_3, \dots, R_r\}$ with each R having a set of skills with an estimation of their competence for each Skill $R1 = \{skill_1Value_1, skill_2Value_2, \dots, skill_sValue_s\}$
- a skill dataset Sk with all the skills that may be required in any project,
- project Pr , with a list Y (required skills list), with a minimum score and a weight value for each skill,
- researchers get a performance score according to the project criteria that they meet.

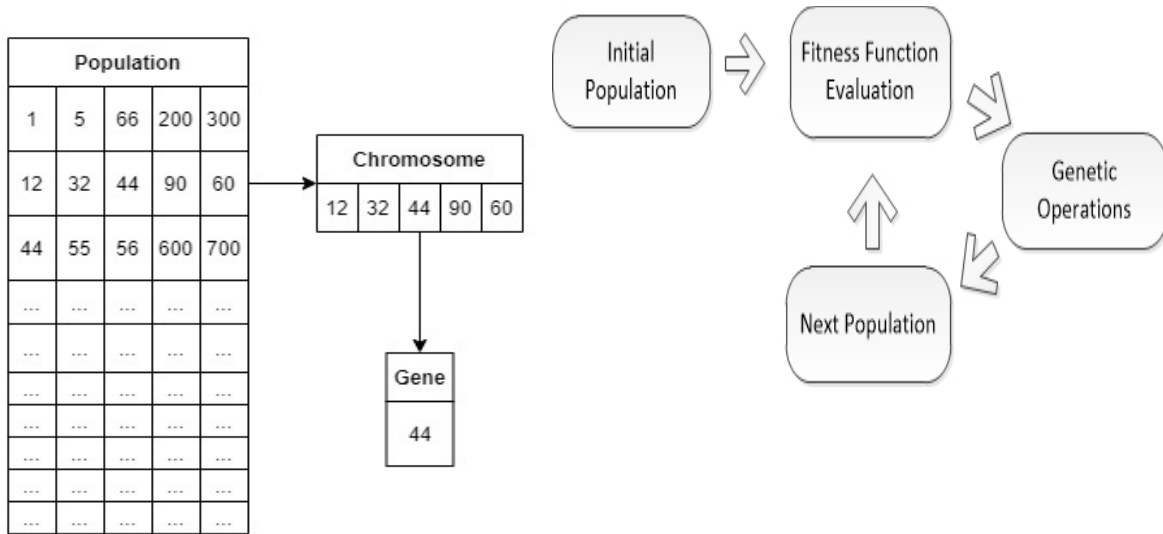
More specifically, team formation problem consists of a set of researchers (eq. 1).

$$Perf\ Score\ (R_i) = \sum_{x=y}^z (Sk_y / MaxVal_y) * (W_y) \quad (1)$$

METHODOLOGY & MODEL REPRESENTATION

Evolutionary Algorithms (EA) is a search-based optimization technique based on the principles of Genetics and Natural Selection. It is frequently used to find optimal or near-optimal solutions to difficult problems which otherwise would take a lifetime to solve. The common feature of these algorithms is that they encode the potential solutions of the problem they face through a chromosome-like data structure, usually an array (Fig.1 Left) and by applying recombination operators they preserve critical information by guiding the evolution process to a satisfactory solution by repeating the evolutionary cycle process (Fig.1 Right). In our study the population, chromosome and gene representation are shown in Fig. 1 where the Gene value is the ID of the researcher.

Fig.1 (Left) Population, Chromosome and Gene representation, (Right) Evolutionary Algorithm Cycle



Each individual chromosome is computed after population initialization. The fitness of each individual is also evaluated as soon as each generation is completed. Since the main goal of our study is to obtain the best team according to project criteria, it is necessary to define a measure for each individual. The fitness of each individual is computed as the sum of skills of all researchers for each skill that is required for the project. We calculate the mean value of the sum of skills of the researchers for all skills that are required for the specific project and then multiple it by the weight per skill (Eq.2). Where x is the number of skills needed for the project and n is the number of the chromosome size (i.e. the team size of the project). In case the mean value of all researchers per skill * weight, is less than the project requirement for the specific skill, then a penalty is imposed on the fitness value that decreases the fitness value a portion almost equal to percentages of the skill difference from the project min value that lagging behind as shown in equation 3.

$$FV = \sum_1^x \frac{(\sum_1^n Rn * Skx)}{Chromosome\ size} Weight_x \quad (2)$$

$$Penalty = \sum_1^x Project_MinskillVal_1 - MeanSkillVal_1 * Weight_1 \quad (3)$$

And the final FV is decreased as show in equation 4.

$$FV = FV - \text{Penalty} \quad (4)$$

In addition, if there is a constraint in researchers' participation then the fitness function checks if these researchers are included in the chromosome. If all necessary researchers are included, no penalty is imposed to the fitness value. However, if at least one researcher is missing then, the fitness value receives a penalty as show in equation 5.

$$FFS = \left(\text{MissingScore} * \frac{\text{ProjectSize} - \text{MissingResearcher}}{\text{ProjectSize}} \right) - 1 \quad (5)$$

Termination condition of our EA is set when either five satisfactory alternative solutions have been found or a specific number of recombination's has been reached (eq. 12) or a specific time period has elapsed. The final step of our process involves the calculation of the deviations between the evaluations of the alternatives for each criterion that were calculated by PROMETHEE method which were produced by the EA in order to find the global preference net flow and the ranking of our solutions.

$$\binom{n}{r} = \frac{n!}{(r!(n-r)!)} \quad (6)$$

The Preference Ranking Organization METHod for Enrichment of Evaluations(**PROMETHEE**) exist to the outranking family of MCDA methods and was developed by Brans and Brans and Vincke (Baghel and Bhavani, 2018; Brans and Vincke, 1985). According to Brans and Mareschal (Brans and Vincke, 1985),PROMETHEE is designed to deal with multi-criteria problems with a finite set of possible alternatives and a set of evaluation criteria which are maximized or minimized. In PROMETHEE, a preference degree is an interpretation of how one action is preferred over another action. This preference degree is a real number between 0 and 1 always. Accordingly, if the criterion is to be maximized, it can be defined as follows.

$$P_j(a, b) = F_j d_j(a, b), \forall a, b \in A \quad (7)$$

where $d_j(a, b)$ is the difference of evaluations among two actions and the preference degree is always between 0 and 1.

$$d_j(a, b) = g_j(a) - g_j(b) \quad (8)$$

A total of six different types of preference functions exists, in which each type defines the way the decision maker prefers one action over another. The final step of this process is the calculation of the unicriterion net flows Φ of each criterion by calculating the Φ^+ and Φ^- . More about multiple criteria decision making methods and their implementation can be viewed in (Papathanasiou and Ploskas, 2018). In our study we apply linear preference function for all the project constraints and complete ranking of our solutions.

RESEARCH STUDY AND COMPUTATIONAL RESULTS

In this study, we create 3000 Researchers with a random number of skills and random values per skill within a pre-defined range (from 0-100) as already mentioned. We set the EA parameters and genetic operators as follows.

Table 1.Evolutionary algorithm parameters.

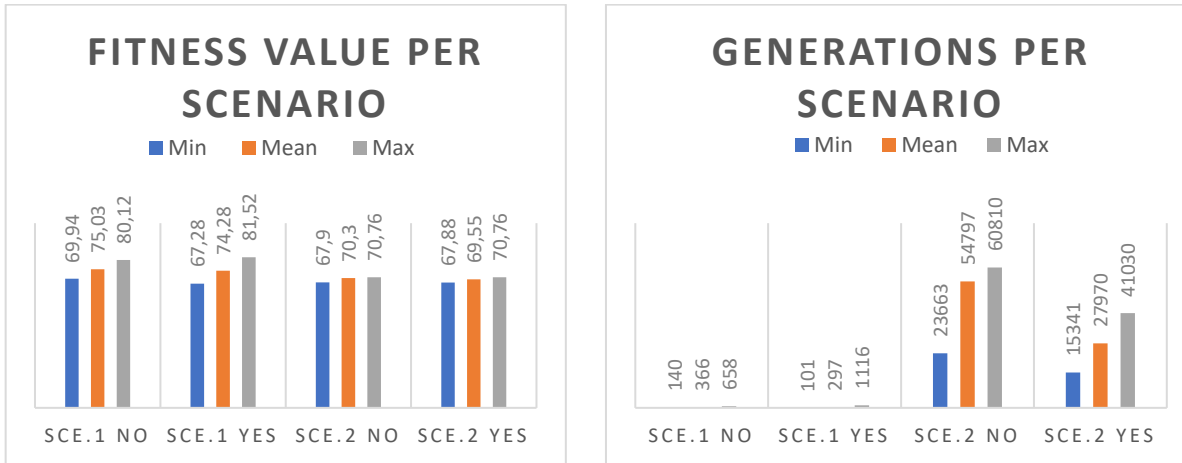
Population Size	50
Selection	Roulette Wheel
Recombination	One-point recombination
Mutation %	0.015% per generation
Elitism	True

As already mentioned, two scenarios were tested with predefined skills, skill weights, and minimum skill values accepted, in order to test the performance of the proposed methodology. The difference in those scenarios is that in one scenario (Constraint Project) we have added the constraint of including specific researchers in our team and in each scenario, we implement a technique that enables the reinitialization of the population.

As the evolutionary algorithm evolves, the fitness value kept increasing in all the cases studies and scenarios, as expected, until a termination condition is met. During this process the EA algorithm was saving the best team that was found at each generation. The top teams with the best scores generated from the EA were introduced as input data to

the PROMETHEE algorithm in order to find the best solution through the multiple-choice process of limited alternatives as show in Table 3. Observing Fig.2, the researcher constraint (Sce.2) had a negative impact. This is due to the fact that the predefined researchers had one of the lowest scores for the project’s criteria in relation to Sce.1 there was no researcher constraint.

Fig.2 Fitness Value Per Scenario (Left), Generations Per Scenario (Right)



The performance of the evolutionary algorithm gets worse temporarily using the option of population reinitialization, but the algorithm explores a bigger search space, since new solutions are added to the population. Storing of best solutions, guarantees that no possible solution will be lost before population reinitialization. In addition, new solutions may be found since the solution space is explored more effectively. This is also illustrated where in the scenario without population reinitialization, three solutions were found while in the scenario with population reinitialization, five solutions were found, until the algorithm was terminated.

Table 2. PROMETHEE computation result examples

	Team Members	EA Score	Promethee NetFlow	Ranking
Sce.2 Yes	Constraint 2- Constraint 1- User 205- User 600- User 1487	68.08	-0.2	4
	Constraint 1- User 1487- User 600- Constraint 2- User 266	68.32	-0.25	5
	User 1639- User 600- Constraint 2-Constraint 1 - User 867	68.68	0.15	2
	User 572- User 601-Constraint 2-Constraint 1 - User 600	70	0.35	1
	Constraint 2-Constraint 1- User 205- User 215- User 572	69.72	-0.05	3
Sce.2	User 600- Constraint 1-Constraint 2- User 266- User 205	69.4	0	2
	User 600- Constraint 1-Constraint 2- User 266- User 1639	69.96	-0.1	3
	User 600 -Constraint 1-Constrain 2- User 572- User1639	70.76	0.1	1

Finally, we have to note that, although PROMETHEE and EA find the best team, in some cases as shown in Table 3 the ranking may differ. This is due to method used to calculate the fitness function, and the penalty imposed to it, when constraints aren’t met. In which PROMETHEE method calculates the preference degree for each criterion between two alternatives ranging from zero to one.

CONCLUSIONS AND FUTURE WORK

The purpose of the hybrid integration has been to utilize the PROMETHEE together with the EA method. From the viewpoint of practical applications, developing hybrid methods has made a more realistic and promising decision than the stand-alone PROMETHEE or EA methods. The work presented in this paper aims to contribute to computer supported team formation models and the main goal was to obtain the optimal or a nearly optimal team that fulfills specific criteria/constraints. Although the experimentation was limited to virtual researchers, the proposed method works with unlimited number of criteria. The results revealed that, the solution space, and constraints play significant role in the execution time and the number of generations needed to find the optimal or a satisfactory solution. Especially, as shown in Fig.3, in the case were specific researchers need to be included in the team, population reinitialization minimizes the

number of generations and execution time by almost 50% which certainly improves the performance of the algorithm. It should be noted that even in cases where there is no optimal solution in the solution space due to the researcher's constraints, the algorithm will nevertheless return us a satisfactory solution. For future work, our goal is to include and quantify qualitative features and data such as communication skills, research characteristics, number of publications, team roles, etc, which certainly have an impact on the team's formation and performance (Lim and Bentley, 2019; Prewett et al., 2018; Rhee et al., 2013).

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Determination of the weights of compliance criteria for the selection of bridge construction method

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Abstract

The subject of this study constitutes a part of a more comprehensive research, which aims to develop a methodology for selecting the most appropriate, per case, among the five current bridge construction methods (Cast-in-place, Precast I-Girder, Incremental Launching, Advanced Shoring method, Balanced Cantilever), in cases of concrete road bridge projects. In the present study, this choice of construction method isn't based only on the economic criterion, which is used to date almost exclusively for this purpose, but it is made on the basis of seven compliance criteria, namely: safety, economy, durability, construction speed, serviceability, aesthetics and environmental harmonization. The management of this large number of criteria becomes possible, in the context of the research, with the help of a valid decision-making tool, such as Multicriteria Analysis, and in particular the AHP multicriteria method. The application of Multicriteria Analysis initially requires the determination of the weights of compliance criteria, which is the main issue of the present paper. However, since this type of research does not provide the possibility of experimental support for its assumptions, it was decided to resort to the opinion of a large number of experts on bridges. Their participation was made through the completion of a suitable Questionnaire. The experts who are participating in the research, come from academia and the construction industry, and are among the most trained engineers in the field of Bridges in Greece. It is noteworthy that in the study, the concrete road bridges are divided into three categories, depending on their importance (bridges of Highways, of National Roads and of Provincial Roads). Therefore, different weights of compliance criteria are calculated for each one of these three categories. The results of the research, which are based on the answers of experts, are presented in detail, through analytical tables.

KEYWORDS

Multicriteria analysis, Compliance criteria, Bridge construction method, Criteria weights, Questionnaire, Experts.

INTRODUCTION

In cases where there is a concrete road bridge project to be constructed, there is a critical need for the selection of the most appropriate bridge construction method. Nowadays, there are five basic bridge construction methods, including: Cast-in-place, Precast I-Girder, Incremental Launching, Advanced Shoring method and Balanced Cantilever. The decision of the selection is not an easy one, since there are many different factors which must be taken into account, such as safety, economy, durability, aesthetics, etc. Therefore, the construction method to be chosen must comply with these factors or criteria, which are usually conflicting. That makes the decision more complex, as a compromise is needed among the criteria.

Regarding the above decision problem, a doctoral research is taking place by the first author and supervised by the second author (entitled: "Multicriteria Analysis for the for the Pre-Selection of the Type of Concrete Highway Bridges"), aiming to develop a methodology for a rational selection of the most appropriate, on a case-by-case basis, among the five current bridge construction methods. In this research, the decision is based on the compliance of the alternative construction methods with seven criteria, which are presented and analyzed in Section 2. The inclusion of this large number of criteria and the management of such a complex problem are achieved through Multicriteria Analysis, which is a valid decision-making tool.

The main topic of the present paper is a part of the above more comprehensive research, and concerns in particular the determination of the weights of compliance criteria, which is absolutely necessary for the implementation of Multicriteria Analysis. More specifically, the calculation of the weights of criteria is achieved through the distribution of a suitable questionnaire to a significant number of Greek experts from various fields of activity in relation to Bridges. Thus, the inclusion of the views of all of them in the final decision is sought, and consequently the determination of some weights with an extent of mutual acceptance, regarding the compliance criteria.

Finally, a particularly interesting aspect of the questionnaire survey is that it does not aim to extract unique weights of the compliance criteria that apply to all road bridges, but instead it aims to extract three different weights distributions, corresponding to the 3 different categories of road bridges that are defined in the study. This will be explained better in Section 4, where the questionnaire is presented.

COMPLIANCE CRITERIA FOR THE SELECTION

As already mentioned, the selection of the most suitable, per case, construction method in a road bridge project should be based on the compliance of the alternative methods with some certain criteria. Even though in practice for years the criterion of economy was taken into account almost exclusively, in the present study in contrast, a more integrated approach to the evaluation of bridge construction methods is attempted. More specifically, seven compliance criteria are used for this purpose, which are: safety, economy, durability, construction speed, serviceability, aesthetics and environmental harmonization. A brief analysis of the concept of each compliance criterion is provided below (Tegos & Markogiannaki, 2019):

- **Safety**

This criterion corresponds not only to the level of safety according to current codes (i.e. Eurocodes) for Bridges, but moreover to the additional level of safety resulting from the response of statically indeterminate structures. In countries with high seismicity, the term safety mainly corresponds to seismic safety.

- **Economy**

The criterion is related to the intended reduction of the cost of the project, yet without devaluation of the rest of criteria. In the context of this study, the criterion of Economy is related only to the construction cost of the project, while the maintenance cost is taken into account in the criterion of Durability. It is noted that in the last years there have been continuous research efforts for the limitation of bridge construction cost.

- **Durability**

The term Durability means the minimization of maintenance needs, during the lifetime of the project. In the case of bridges, maintenance needs are associated with the use of bearings, joints and seismic dampers. As mentioned above, the maintenance cost of a bridge is reflected in the performance of the criterion of Durability, and not in the one of Economy. It is notable that sometimes maintenance cost could even reach the construction cost level.

- **Construction speed**

The criterion of Construction speed is directly related to the expected completion time of the project, which is intended to be minimized. The (average) construction speed is defined here as the ratio of the length of the bridge deck to the total construction time of the bridge (i.e. the deck, the abutments, the piers and their foundations). The aforementioned total construction time includes also the assembling, disassembling and transfer times of the necessary mechanical equipment used in the construction.

- **Serviceability**

The usual concept of serviceability is linked to the quality of traffic service; however, in this study, the term "Serviceability" means the development of an adequate structural response to the imposed deformations (namely the expansion and contraction of the deck) during the operation phase of the bridge. It is noteworthy that the use of bearings is the best solution to the problem of serviceability.

- **Aesthetics**

The concept of Aesthetics in the field of bridges includes certain established rules related to the choice of geometric dimensions, which attempt to reconcile safety and geometric proportions that contribute to an aesthetic effect. Some indicative rules are the following: All piers should have the same width; the variability of height of the deck cross sections (arc shape) is positively evaluated, etc.

- **Environmental harmonization**

The criterion of Environmental harmonization is related to the existing architectural tradition of the area, as well as to the surrounding landscape of the bridge. These two factors should affect the selection of the deck type and the geometric dimensions, which must both be in harmony with them. Moreover, the concept of this criterion includes the desirable minimization of landscape alteration and environmental impact in the area caused by the bridge project.

MULTICRITERIA ANALYSIS

3.1 Definition

Multicriteria Analysis (MCA) is a widespread application of Operations Research in decision-making. The objective of this method is the systematic and mathematically standardized effort to solve decision-making problems, where there are a number of alternative choices and many conflicting criteria are involved (such as the above-mentioned ones, related to the selection of bridge construction method). The method aims eventually to achieve a rational compromise among these criteria, in order the optimal choice to be made.

3.2 The AHP Multicriteria method

The specific Multicriteria analysis method used in this study is the Analytic Hierarchy Process (AHP), which was developed by T.L. Saaty in USA in 1977 and is one of the most widely used MCDA approaches. As far as its mode of functioning is concerned, the AHP method structures hierarchically a complex multicriteria problem; essentially it decomposes the problem into its constituent parts, and then focuses separately on each hierarchy level. At the top of the hierarchy is the objective; at the intermediate levels are criteria, while the lowest level contains the list of alternatives (Kamal, 2001).

At each level, successive pairwise comparisons of its elements are performed, by using Saaty's numeric scale (Saaty, 1980). This scale provides a quantitative expression of the decision maker's intuition, experience and knowledge regarding the extent to which one factor dominates over another one of same level. This stepwise procedure results to the determination of the relative weights (priorities) of the criteria initially, and of the alternatives afterwards, while eventually it provides the final rank of the alternatives. The present paper, in particular, focuses only on the initial stage of this procedure, namely the determination of the weights of criteria, which is performed through the questionnaire survey.

SUMMARY PRESENTATION OF THE QUESTIONNAIRE

The Questionnaire, which is in Greek, has the same title as the present paper. The experts, to whom the questionnaire was addressed for this study, are ten and come from either the construction industry or the academic / research field, while they are among the most trained engineers in the field of Bridges in Greece. The content of the Questionnaire is briefly presented below, divided into subsections.

4.1 Profile of the participants

Initially, there are three questions about the profile of the experts (engineers) that participate in the survey: In the first one, the experts are asked about their main field of activity in relation to Bridges, having 5 possible answers, such as: Private sector, Public sector, Academic field, etc. In the second one, they are asked about the type of their employment in relation to Bridges, with 7 possible answers: Designer, Project manager, Academic, Researcher, etc. Finally, the third question concerns the years of their experience in the field of Bridges (up to 5 years, 5-10 years, 10-20 years, or more than 20 years).

4.2 Necessary information for the experts

Subsequently, the experts are provided with some necessary information or explanations for completing the Questionnaire, such as: 1) the subject of the doctoral research, part of which is this survey, 2) a brief definition of Multicriteria Analysis, 3) the goal of the Questionnaire, 4) a simple reference to the alternative construction methods, 5) the compliance criteria used in the survey. Afterward, the participants are provided with a brief analysis of the concept of each compliance criterion, which is the same as in Section 2.

4.3 Explanation of the triple version of the Questionnaire

In the present study, the concrete road bridges are divided into three categories, depending on their importance (bridges of Highways, of National Roads and of Provincial Roads). Consequently, three different distributions of weights of the compliance criteria need to be calculated, one for each different category of bridges. That means that the experts

are asked to complete the Questionnaire in its triple version, i.e. three similar sub-questionnaires, essentially with the same questions each, but from a different point of view.

This categorization is essential, as it's obvious that the priority (weight) of many criteria varies, depending on the importance of the road containing the bridge in question. E.g. it is reasonable that in the bridges of Provincial roads the criterion of Economy is usually predominant, while in the bridges of Highways in particular, other criteria (for example, durability or aesthetics, etc) could have a significant weight. Another notable difference is that the Highways are usually built in a new environment, while the National and Provincial roads near residential areas or existing road networks, with more restrictions on construction.

4.4 The main Questionnaire

What follows is the main part of the Questionnaire. This contains the three similar sub-questionnaires, from which: one is dedicated to questions about bridges of Highways, one to questions about bridges of National Roads and one to questions about bridges of Provincial Roads. As mentioned above, the questions in each sub-questionnaire are exactly the same; however the experts are asked to answer to each sub-questionnaire from a different perspective each time.

Each sub-questionnaire contains 22 questions, from which:

- The first one asks from the experts to make a preliminary prioritization of the seven compliance criteria, depending on their importance in the process of selecting a bridge construction method. The goal of this question is the experts to form an initial opinion on the subject, before the main questions.
- The questions 2-22 contain the successive pairwise comparisons of all the compliance criteria. This means that each criterion is compared to every other criterion. These questions have all the same pattern and consist of 2 parts:
 - i. In the first sub-question, the experts are asked which criterion of the 2 of the respective pair (e.g. safety or durability) is more important, while they also have the choice of answering that they are equivalent in importance.
 - ii. In the second sub-question, they are asked to rate the degree of predominance of the criterion they have chosen above, over the other. The possible answers are 5 adverbs that express a gradual increase, i.e. that the criterion predominates: imperceptibly / slightly / appreciably / significantly / catalytically. Each adverb corresponds to a value of scale 1-5, which is used subsequently for the application of the Multicriteria analysis method of AHP.

PRESENTATION OF THE RESULTS OF THE QUESTIONNAIRE

The answers of the ten experts in the Questionnaire were converted into values in Multicriteria analysis, the application of which led to the final weights of compliance criteria (the averages), concerning the bridges of Highways (Table 1), the bridges of National Roads (Table 2) and the bridges of Provincial Roads (Table 3):

Table 1: Experts' weights of compliance criteria for the bridges of Highways

Experts Criteria	1	2	3	4	5	6	7	8	9	10	Average
Safety	0,248	0,266	0,290	0,279	0,269	0,260	0,246	0,279	0,288	0,302	0,273
Durability	0,212	0,253	0,258	0,186	0,265	0,175	0,151	0,219	0,192	0,168	0,208
Economy	0,171	0,136	0,136	0,186	0,164	0,192	0,302	0,153	0,184	0,133	0,176
Aesthetics	0,107	0,099	0,073	0,100	0,049	0,116	0,041	0,052	0,082	0,043	0,076
Constr. Speed	0,100	0,096	0,106	0,099	0,112	0,127	0,096	0,104	0,114	0,092	0,105
Serviceability	0,092	0,075	0,075	0,088	0,089	0,065	0,125	0,143	0,087	0,216	0,105
Environ. harmon.	0,070	0,075	0,062	0,062	0,052	0,065	0,039	0,050	0,053	0,046	0,057

Field of activity of Experts:

Exp. 1: Academic, Exp. 2: Research, Exp. 3: Research, Exp. 4: Private sector, Exp. 5: Private sector, Exp. 6: Private sector, Exp. 7: Public sector, Exp. 8: Private sector, Exp. 9: Public sector, Exp. 10: Public sector

Table 2: Experts' weights of compliance criteria for the bridges of National Roads

Criteria	Experts										Average
	1	2	3	4	5	6	7	8	9	10	
Safety	0,203	0,228	0,226	0,224	0,308	0,234	0,278	0,254	0,253	0,253	0,246
Durability	0,130	0,144	0,123	0,135	0,200	0,117	0,178	0,173	0,117	0,151	0,147
Economy	0,222	0,207	0,245	0,220	0,173	0,234	0,098	0,191	0,214	0,218	0,202
Aesthetics	0,071	0,073	0,057	0,070	0,066	0,070	0,057	0,045	0,064	0,057	0,063
Constr. Speed	0,195	0,159	0,199	0,177	0,145	0,159	0,229	0,143	0,180	0,151	0,174
Serviceability	0,116	0,119	0,095	0,115	0,044	0,117	0,109	0,131	0,119	0,113	0,108
Environ. harmon.	0,063	0,070	0,055	0,059	0,064	0,069	0,051	0,063	0,053	0,057	0,060

Table 3: Experts' weights of compliance criteria for the bridges of Provincial Roads

Criteria	Experts										Average
	1	2	3	4	5	6	7	8	9	10	
Safety	0,174	0,144	0,138	0,191	0,154	0,176	0,241	0,217	0,208	0,278	0,192
Durability	0,114	0,160	0,114	0,113	0,128	0,115	0,160	0,184	0,113	0,231	0,143
Economy	0,237	0,236	0,261	0,226	0,284	0,232	0,228	0,225	0,233	0,135	0,230
Aesthetics	0,062	0,067	0,074	0,059	0,040	0,065	0,052	0,041	0,057	0,045	0,056
Constr. Speed	0,211	0,196	0,241	0,208	0,210	0,232	0,115	0,188	0,208	0,178	0,199
Serviceability	0,136	0,130	0,111	0,131	0,117	0,115	0,151	0,094	0,120	0,088	0,119
Environ. harmon.	0,066	0,067	0,061	0,072	0,067	0,065	0,053	0,051	0,061	0,045	0,061

As shown in the footnote under Table 1, there is a variety regarding the (main) field of activity in relation to Bridges, which was stated by the 10 experts. Thus, there were 4 experts from Private sector, 3 experts from Public sector, 2 experts from the Research field and 1 expert from the Academic field.

The results concerning the final weights of compliance criteria (i.e. the averages of the 10 individual weights distributions of the experts, per bridge category) show some clear differences among the three final distributions of weights of criteria corresponding to the three bridge categories (bridges of Highways, of National Roads and of Provincial Roads). These obvious differences in the final rankings justify the choice made in the research, to treat the three bridge categories separately, depending on their importance.

CONCLUSIONS

The main conclusions derived from the present study are the following:

- In all three bridge categories, the criteria of Safety and Economy are always in the first 3 places in the final weights distributions, and always one of them is in the first place. On the contrary, the criteria of Aesthetics and Environmental harmonization are clearly underestimated in the preferences of experts, in almost all three cases.
- There are notable differences between the preferences in the compliance criteria of the experts from the Academic and the Research field (which could be considered theoreticians, i.e. the experts 1, 2 and 3) and those from the Private and Public sector (designers, project managers, etc. coming from the field of applications, i.e. the rest of the experts).
- The resulting weights of compliance criteria could be possibly utilized by Awarding Authorities for the evaluation and the assignment of the optimal design approach for bridge projects.

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A PROMETHEE multi-criteria analysis for the EU countries using EPI data

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Abstract

The Environmental Performance Index (EPI) is receiving increasing attention as concern about environmental problems grows year by year. This index includes some of the most important dimensions, which can affect the natural environment and characterize the quality of life. It develops a ranking among the selected countries (180), and it is published on an annual basis by Yale University and Columbia University in collaboration with the World Economic Forum. The EPI uses a specific approach, discussed later in this paper, which focuses on how close each country is to a predetermined goal. Using the published data by the EPI, we are going to develop a model in PROMETHEE. More specifically, in this paper, we are going to focus on the EU countries. Thus, we will use the published data of 2020 in order to process them with PROMETHEE, a well-known multiple criteria decision analysis method. The purpose of this work is to create a comparison of the two final rankings, EPI's ranking, and PROMETHEE's ranking, studying how the two methodologies react to the final results, one methodology that compares its country's performance with a predetermined target (EPI) and the other methodology that makes pairwise comparisons between input data (PROMETHEE). For this purpose and intending to use as much detail as possible in our model for forming a similar base with the EPI, we are going to use the EPI's 11 indicators for PROMETHEE's comparisons, which are developed under two main categories, the category of Environmental Health and the category of Environmental Vitality.

KEYWORDS

multi-criteria analysis, PROMETHEE, Environmental Performance Index.

INTRODUCTION

We will use the EPI data for EU countries published for 2020 creating a case study using PROMETHEE

Environmental problems are increasingly widespread and their negative effects are becoming more and more apparent. In the coming years, the environmental changes that man will experience will be particularly intense. Almost every major ecosystem has been impacted by human activities, and in many cases, the damage is obvious. As pollution is increasing, geologists worry that the negative effects will form a wholesale alteration of the Earth's natural environment and our era will face challenges that the human race has never faced before (Zalasiewicz et al., 2008).

As a consequence, the research community is seeking to measure and determine the extent of environmental problems. Under this perspective, the Environmental Performance Index (EPI) tries to measure how well the selected countries perform in a two-dimensional direction; protection of human health from environmental harm and protection of every ecosystem. The EPI addresses as many as environmental aspects as possible and creates a ranking of the countries. In order to create the ranking, the EPI uses a specific approach, which focuses on how close a country is to a pre-defined goal, and it will be analyzed later in this paper.

Taking the data of EPI's 2020, including all its following 11 sub-categories under the two main dimensions (protection of human health from environmental harm and protection of ecosystems), we will construct a model for PROMETHEE ending up with its ranking to compare the results with the report of the EPI. We will use the data for all the EU countries. Our purpose is to explore whether EU countries perform the same by examining their data using a different method of ranking.

ENVIRONMENTAL PERFORMANCE INDEX

The Environmental Performance Index (EPI) is developed by a data-driven summary of sustainability around most countries of the world. It uses 32 indicators to measure each country's performance across 11 sub-categories, and as a result, it provides a ranking of 180 countries, based on two main categories of indicators, environmental health, and ecosystem vitality. Both these indicators offer a national assessment of how near each country is to a set of environmental policy goals. (Wendling, & et al., 2020)

Every year the indicators' EPI are becoming more representative and enlarged in order to form a constantly updated and complete image for each country, and today it is the major measurement framework for global environmental policy analysis. 2020 is the 22nd year of EPI's publication, and it includes new metrics that monitor waste disposal, carbon dioxide pollution from ground use transition, and fluorinated gas emissions, which are all also significant drivers of climate change. **Invalid source specified.**

The methodology of EPI is based on multiple steps that lead to the indicators' development. In general, as a first step, the raw data of each country are divided by GDP population, or other common denominators to make them comparable among countries. The second step is a logarithmic transformation that is being applied to most of the variables. After that, the indicators are being shaped by the transformed and logged data, using a proximity-to-target methodology. This methodology measures a country's performance on each indicator depending on its position within a range established by the lowest-performing country (in a 0 to 100 scale) and a specific target, which is equivalent to 100. In the final step, the aggregate EPI score is being developed by explicit weights, which are assigned to each indicator, policy category, and objective. (Emerson et al., 2012; Hsu et al., 2014)

PROMETHEE

The PROMETHEE method (Preference Ranking Organization METHod for Enriched Evaluation) is a well-known multiple criteria decision aid method, and it belongs to the outranking methods, like the ELECTRE method. The decision-maker who uses PROMETHEE will have a ranking of the selected alternatives based on the preference degree's computation **Invalid source specified.** This method requires two types of information, the criteria's weights and the preference function's type (Usual, U-shape, V-shape, Level, Linear and Gaussian), while depending on the type, the decision-maker should decide about the suitable thresholds **Invalid source specified.** In our model, we are going to use the Linear preference function type, and thus we will set the required thresholds, which are the preference (P) and indifference (Q) thresholds. More specifically, if the gap between evaluations of a criterion is smaller than the indifference q threshold, then the decision-maker will detect no distinction between such two actions (i.e., the degree of preference is 0). Whether the difference is larger than the value of preference p, then the preference is high (i.e. the degree of preference is 1). **Invalid source specified.**

The core of PROMETHEE's methodology consists of 3 main steps, and the criteria can be qualitative and/or quantitative. Firstly, it calculates the preference degree of each action on each criterion, based on whether one option/alternative is more preferred over the others. The values are between 0 (no preference) and 1 (strong preference). Then the methodology continues with the calculation of every criterion's flows (unicriterion flows), which measures which alternative is more preferred over the others, at the level of each criterion. The values here are expressed through positive, negative, and net flows. Unicriterion positive and negative flows are between 0 and 1, while unicriterion net flows are between -1 and 1 as they are the subtraction of negative flows from positive flows. The final step of the PROMETHEE method calculates all criteria's global flows, considering all criteria together and a final ranking (from the best alternative to the worst alternative) is developed. Specifically, the subtraction of the negative global flow from the positive global flow leads to the global net flows. The global positive and negative flows are the result of the PROMETHEE I partial ranking, and the final ranking with the global net flows is the result of the PROMETHEE II complete ranking. **Invalid source specified.**

CASE STUDY

Data

The data that we are going to use are the published 2020's data of EPI by the Yale and Columbia Universities¹. In Table 1 there are all the EPI's indicators, where firstly there are two main categories of indicators (Health and Ecosystem Vitality), then each one of them it is separated in other indicators' sub-categories (4 sub-categories in Health and 7 sub-categories in Ecosystem, 11 in total), and the final level is consisted of the specific indicators on each sub-category. In general, we can observe that the Health Indicator evaluates the protection of human health against environmental damage, while the Ecosystem Vitality Indicators attempts to measure the protection and preservation of ecosystems.

Table 1. EPI's Indicators

Environmental Performance Index		
Health	Ecosystem Vitality	
Air Quality	Biodiversity	Climate Change
PM2.5	Terrestrial biomes (nat'l)	CO2 growth rate
Household solid fuels	Terrestrial biomes (global)	CH4 growth rate
Ozone	Marine protected areas	F-gas growth rate
Sanitation & Drinking Water	Protected Areas Rep. Ind.	N2O growth rate
Sanitation	Species Habitat Index	Black Carbon growth rate
Drinking water	Species Protection Index	CO2 from land cover
Heavy Metals	Biodiversity Habitat Index	GHG intensity trend
Lead	Ecosystem Services	GHG per capita
Waste Management	Tree cover loss	Pollution Emissions
Solid waste	Grassland loss	SO2 growth rate
	Wetland loss	NOx growth rate
	Fisheries	Agriculture
	Fish Stock Status	Sustainable N Mgmt Index
	Marine Trophic Index	Water Resources
	Fish caught by trawling	Wastewater treatment

In our model, we are going to use the 11 indicators of the above sub-categories as criteria, and the 27 EU countries as alternatives.

Table 2 Preferences

Preferences	Air Quality	Sanitation Drinking Water	Heavy Metals	Waste Management	Biodiversity	Ecosystem Services	Fisheries	Climate Change	Pollution Emissions	Agriculture	Water Resources
min/max	max	max	max	max	max	max	max	max	max	max	max
Weight	0,20	0,16	0,02	0,02	0,15	0,06	0,06	0,24	0,03	0,03	0,03
Preference Function	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear	Linear
Thresholds	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute	absolute
Q: Indifference	15	15	15	15	15	10	5	10	10	15	15
P: Preference	60	70	70	80	70	20	10	70	90	30	80

In Table 2 there are all the needed details about the model's preferences. Every criterion is preferred to be maximized, the selected weights are the same as the EPI's model, with the sum of 1. A linear preference function has been selected

¹ The data are officially published at <https://epi.envirocenter.yale.edu/>.

because we have quantitative parameters and the thresholds were also appropriate to reduce the effect of the countries' relatively similar values. According to the data the values of the indifference threshold q of the preference threshold p are chosen. For example, the average of the Air Quality Index is 72,68, thus a Preference threshold equal to 60 is chosen, in order to focus on the best performances.

Results

Table3 PROMETHEE & EPI Rankings

PROMETHEE's Ranking	Country	EPI's Ranking	Order's difference
1	Denmark	1	0
2	Germany	7	-5
3	France	3	0
4	Sweden	6	-2
5	Finland	5	0
6	Austria	4	2
7	Netherlands	8	-1
8	Luxembourg	2	6
9	Malta	15	-6
10	Italy	14	-4
11	Ireland	11	0
12	Greece	16	-4
13	Belgium	10	3
14	Spain	9	5
15	Cyprus	20	-5
16	Portugal	18	-2
17	Romania	21	-4
18	Estonia	19	-1
19	Slovenia	12	7
20	Czech Republic	13	7
21	Slovakia	17	4
22	Croatia	23	-1
23	Bulgaria	27	-4
24	Lithuania	25	-1
25	Poland	26	-1
26	Hungary	22	4
27	Latvia	24	3

The two methodologies of ranking have a quite different perspective to calculate the performance of each country, and thus they have different final results. PROMETHEE takes into consideration the performance of all countries, while the EPI calculates each country's performance towards a defined target. However, we can not claim that the two rankings are totally different. It can be observed a partial grouping among the two rankings.

More specifically, as we can see in Table 3, Denmark is the first country on both rankings, but despite that, Luxembourg ranks eighth in the PROMETHEE's ranking and second in the EPI's ranking. The reader can easily observe the differences between the two rankings. In total, there are three countries that have the same position, and the biggest difference is seven positions that can be observed by two countries (Slovenia and Czech Republic). Furthermore, the average of difference is about 3, which is not a big difference among the two rankings. But taking everything into consideration, there is a point that PROMETHEE is distinct from the EPI's methodology. PROMETHEE does not only calculate the best performance of every country, but it compares every performance to all the others, and thus it ends up with a final ranking that has calculated the best performance in relation to all performances.

4.3 Sensitivity analysis

A sensitivity analysis is an important and helpful tool in order to measure how robust the ranking is. When a criterion's interval is restricted, then the ranking is quite sensitive to any change. In other words, if a value changes more than the percentage of the interval, then the final ranking will be changed too. In our model, the sensitivity is high. In Table 3,

the reader can observe all the intervals of every criterion. Most of them are really strict and that means that our ranking is not characterized by robustness. Only two criteria, Biodiversity and Pollution Emissions, do not have such strict intervals compared to the rest.

Table3 Sensitivity analysis

Air Quality	Sanitation Drinking Water	Heavy Metals	Waste Management	Biodiversity	Ecosystem Services	Fisheries	Climate Change	Pollution Emissions	Agriculture	Water Resources
[19,04%, 20,02%]	[15,70%, 17,55%]	[1,63%, 2,26%]	[0,30%, 2,38%]	[7,72%, 15,00%]	[5,95%, 6,20%]	[5,54%, 6,01%]	[20,46%, 24,11%]	[1,83%, 7,40%]	[4,58%, 5,08%]	[5,63%, 7,02%]

CONCLUSIONS

Having considered everything presented in this paper, the main conclusion that can be drawn is that the two methodologies of EPI, an index that calculates a country's environmental performance, and PROMETHEE, a multiple criteria decision analysis method, have quite different approaches, but in the used model the differences in the final two rankings were not really high. Of course, it will not be wise to draw complete conclusions from this model, as it was an isolated case for only one year, but the approach can be useful to create a broader picture of each country's performance to environmental problems. Nevertheless, it is quite important that environmental issues be thoroughly analyzed by any methodology or approach that may be useful to study and analyze them with the aim to learn more, reverse and improve the difficult environmental situation that we face today.

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Session 9:
Business Process Management: Simulation
chair: Pavlos Delias

Business Process Management Simulation in Academic Libraries: A Case Study

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Abstract

Although several studies have demonstrated the utility of computer simulations, there is still a lack of real case applications, especially in the area of academic libraries. At the same time libraries are increasingly expected to provide qualitative services at a lower cost, reinforce their customer focus and track control processes. Libraries face resource shortages, long waiting times and financial losses. Libraries' staff often complains dissatisfaction in a high stress work environment. In this paper a case study was implemented presenting the business process modeling of the circulation department at the library of the University of Macedonia. The department of circulation is the point of service at which books and other materials are checked in and out of the library. Following interviews with the library's staff, and through an accurate quantitative analysis, the current situation as it is (As-Is model) was analyzed. Then, simulation using the Business Process Management (BPM) framework was used to identify and understand the movement of entities and their inefficiencies and threats. Finally, the study of the As-Is model in different activities can indicate improvements in the business model of the library, and the results can be analyzed to minimize time, costs and resources.

KEYWORDS

Business Process Management; Process Analysis; Business Process Modeling; Process Efficiency; Academic library.

INTRODUCTION

Public sector organizations today are constantly seeking to modernize their operations, while providing customers more reliable and customized services. More and more public organizations need to cut their expenses so that they can deal with severe budget cuts and find ways to do more for less (Angelopoulos et al., 2010; Leva and Sulis, 2017; Papadopoulos et al., 2018). Organizations aim to increase customer loyalty and make services more accessible to consumers (Kitsios and Kamariotou, 2020; 2019a). Similarly, developments in the socio-economic environment have profoundly changed the functioning of academic libraries around the world. Academic libraries have experienced significant cost reductions due to reduced financial resources and digitalization of facilities and services over the last decade (Siguenza-Guzman et al., 2014; Kostagiolas et al., 2016; Saunders, 2015).

Although several studies have demonstrated the utility of computer simulations, there is still a lack of real case applications, especially in the area of public management. That is where modern Business Process Management (BPM) tools and techniques are designed to reduce manual effort by automating business processes. It helps to overcome all barriers between tools, information systems and people through process analysis (Kitsios and Kamariotou, 2019b; 2017a). Therefore, the implementation of BPM for organizations in the public sector will become a strong ally in meeting operational challenges in order to provide better and qualitative public facilities (Leva and Sulis, 2017; Papadopoulos et al., 2018).

There are two key reasons for the public sector to incorporate BPM in its services. The first is the urge to modernizing infrastructure and making them as digital as possible while adopting a business model with lower cost. The second is the desire to provide higher quality services that are easily provided (Santana et al., 2011). Public sector organizations are faced with further challenges, including major gaps in the adoption of the BPM from private businesses. There are some main distinctions between the public and private sectors, namely: public interest, transparency, the factors that impede reform, the mechanism of policy transition, and culture (Papadopoulos et al., 2018). As occurs in the private sector, there is a multitude of strengths-barriers that make it difficult to effectively enforce the procedure management of the public sector. The fact that there are challenges is not just something that arises in the public sector's peculiarity lies in the root of these discrepancies (Niehaves and Plattfaut, 2010).

Therefore, the purpose of this paper is to implement a case study in order to present the business process modeling of the circulation department at the library of the University of Macedonia. The department of circulation is the point of service at which books and other materials are checked in and out of the library. Following interviews with the library's staff, and through an accurate quantitative analysis, the current situation as it is (As-Is model) was analyzed. Then, simulation using the Business Process Management (BPM) framework was used in order to see how entities flow and to detect and understand inefficiencies, and risks.

The layout of this paper is as follows sections: The next section, after a brief introduction to this area, is the theoretical background in respect of BPM framework. Section 3 presents the of the circulation department at the library of the University of Macedonia proposed modeling. Finally, conclusions are presented in Section 4 and the paper ends.

BPM IN THE PUBLIC SECTOR

The public sector has always been slower than the private sector as it adopted emerging technologies. This situation can have some benefits for the public sector because we can pick and enforce only the "proven" best practices in the private sector (Kitsios and Kamariotou, 2017b). There is a variety of potential public sector applications for BPM. Approval processes are complex, sluggish and not well run in most public agencies, leaving a large gap for change through the introduction of BPM (Jurisch et al., 2013). A significant benefit of BPM is that it is so easy to suit the different business processes. A major benefit of BPM is that it is so easily adapted to suit individual organizations' unique business processes and can quickly and cost-effectively incorporate different IT systems and parts of the organization. It helps to establish a cohesive image of the company, with all its processes and arrangements of resources (Recker, 2010). Business processes management allows for the modernization of the old public process by aligning information technology with organizational management in an organizational operation which is generally more effective (Gulledge and Sommer, 2002).

According to Genon et al., (2011) and Gulledge and Sommer, (2002) BPM has important benefits in Improved alignment of public administration with resource management goals, integration of policy, strategy and organizational execution, improved transparency and accountability oversight, continuous improvement of services delivered, improved efficiency and cost savings, quicker responses to policy changes and unplanned incidents and growth. Certain advantages include greater efficiency, improved team-alignment and standardization, and faster recruitment and training of new workers. BPM opens the door to innovative and inventive approaches in order to improve organizational performance, encourages the successful introduction of current processes and standard applications as most new implementations are process-oriented, promote reporting, research, collaboration and communication. Improving process efficiency, promoting the integration of activities, the organizational plan and the introduction of Quality Management Systems (ISO 9001) and encouraging organizational activity analysis through the use of BPM tools and techniques to model actual organizational work are also significant benefits of BPM. Possible versions used as a basis for the business process improvement of managers and the automation of suggestion solutions.

CASE STUDY

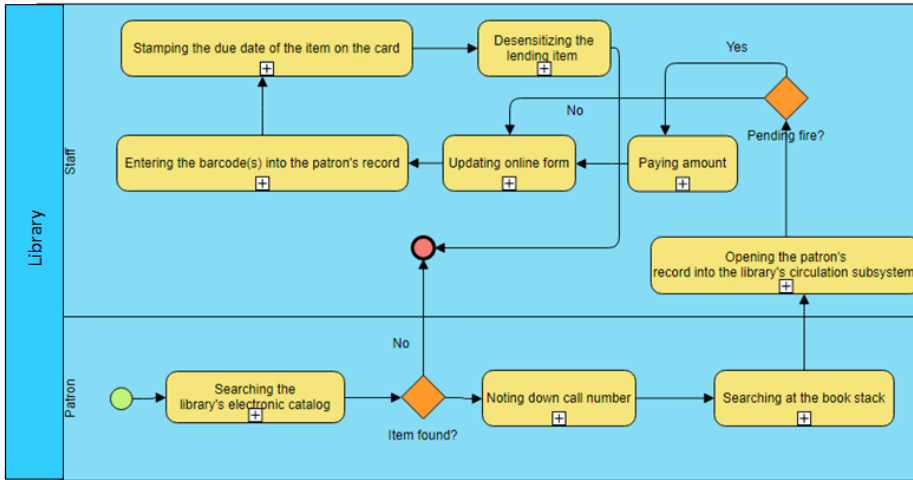
The research library being researched is the University of Macedonia's library and information centre, Thessaloniki. The University is a middle-sized educational institution with eight academic faculties, providing up to the doctoral level a wide variety of undergraduate and postgraduate courses. The department of circulation is the point of operation at which books and other items are checked in and out of the library. The circulation department is considered to be the library's most critical department, because it manages loan and the cycle of return. It also provides other processes, such as renewal, payment of fines, and shelving. The five most important procedures, according to the staff, are: principal collection lending process, reserve collection lending process, return process through the main collection, return process through the drop box and extension process (Kissa et al., 2019).

The patron (student, professor, citizen) during the lending process of the main collection, searches the online catalog of the library, to find out whether a copy of the item is already available for borrowing. When it is available for lending and the patron wants to borrow it, he has to write down his call number (i.e. unique identification number for each title in the series) and look it up at the main collection's book shelf. If he/she finds it, he carries it to the main desk of the library. The first librarian available at the circulation desk can request the patron's borrowing card. She / he uses the borrowing card's barcode to access the patron's record inside the library's circulation subsystem (part of Library's Operating System) to initiate the lending transaction. When the patron has an unpaid fine, the operation cannot be carried out in compliance with the lending law of the current library unless the fine is paid at the lending desk. The librarian has to inform the patron of the amount payable. The patron must pay the fine in cash or by credit card at the main desk and the librarian changes the electronic form of the library's operating system and sends the patron a receipt as proof of payment. The librarian inserts, one by one, the barcode(s) of the item(s) in the patron's record. To complete

the lending process, the librarian stamps the item's due date on the attached card on the last page of the lending item. Finally, the librarian uses the necessary equipment to desensitize the lending object, and handles it to the patron (Kissa et al., 2019).

Figure 1 presents the modeling of the lending process of the main collection using the BPMN framework.

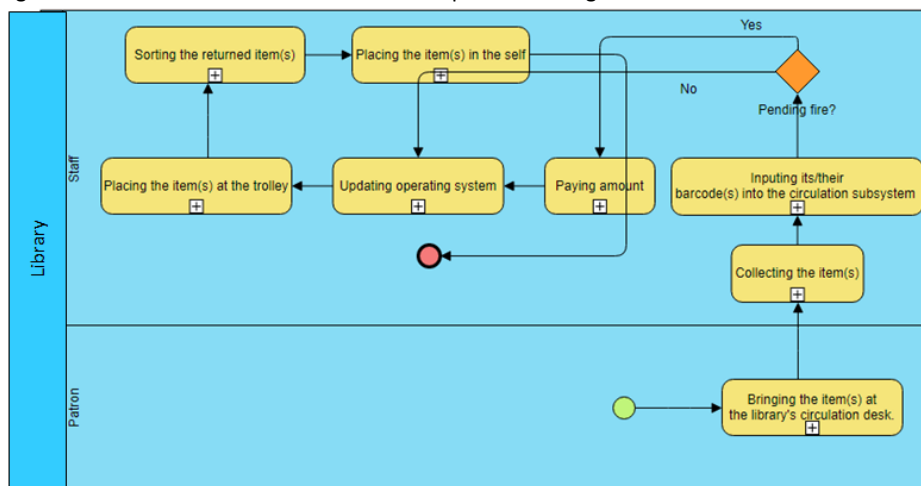
Figure 1 Business Process Model of the lending process of the main collection



The patron brings the item(s) to the library during the return process via the main collection. The first available librarian in the circulation desk gathers item(s) from the patron and inserts his / her barcode(s) into the circulation subsystem of the library's operating system. The librarian searches for right patron name. If any unpaid fines appear in the system, the librarian will ask the patron for a borrowing card to verify the amount payable. The librarian has to inform the patron of the amount payable. The patron must pay the fine in cash or by credit card at the main desk and the librarian changes the electronic form of the library's operating system and sends the patron a receipt as proof of payment. The librarian sensitizes the item(s) and places them in the return item trolley. All morning shift librarians sort and put the returned items in the shelf each morning and every midday (Kissa et al., 2019).

Figure 2 presents the modeling of the return process through the main collection using the BPMN framework.

Figure 2 Business Process Model of the return process through the main collection



CONCLUSIONS

Organizations in the public sector are obligated to make structural improvements and improve the use of their resources. All that can be done by the introduction of information systems such as BPM into public sector organizations. The paper clearly illustrates that business processes management has many advantages for an organization in the public sector. Organizations in the public sector have been challenged overwhelmingly with various challenges such as pressure for productivity, better results, openness and increased accountability. Public sector organizations have also

seen a rise in BPM's demand for public sector application in general. Through this way the model is a very useful tool for evaluating the behaviour of the system through various working environments and for obtaining valuable tips for management of the department and process reengineering. BPM will incorporate all the processes, data and services to improve operations, time, and resources. It can also considerably improve the services offered to make them more useful to customers. While this paper clearly illustrates the many benefits of implementing BPM for the public sector, further research is needed on how the process of patrons searching for books on the online catalog can be evaluated. Another avenue for future research is to simulate the lending process of the reserve collection, the return process through the drop box and the renewal process.

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An inclusive representation approach to assess the redesign capacity of BPMN models

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Abstract

Business Process Redesign (BPR) encompasses various techniques for modifying the process design, depending on the feedback of the process run-time, and/or the performance attributes. Although a detailed analysis of a business process typically sparks assorted ideas and perspectives for redesign, it is usually conducted in a non-systematic way, and is predominantly considered a creative activity. So far, only a few redesign approaches in literature investigate how the improvement procedure can be methodologically supported to reduce the uncertainty from the AS-IS to the TO-BE process. What is also overlooked is the evaluation of the BPR impact prior to its implementation, since the majority of approaches deal with BPR at runtime. The proposed approach of the research presented in this paper introduces a representation method that incorporates a visual and quantitative perspective. The latter is a combination of the established Business Process Model and Notation (BPMN) 2.0 standard and an adapted graph-based structure, initially designed for agent concepts. It encompasses an inclusive set of BPMN elements and a list of ordering constraints from declarative business process modelling, to capture the execution logic of each model. The application of the representation method to a typical business process model showcases: (a) the a priori evaluation of input models in terms of redesign capacity, and (b) the fact that it is amenable to cost-based optimization techniques. Given a business process model in the proposed representation, a practitioner is assisted towards redesign decision making at an earlier-than-runtime stage, to avoid unnecessary risk.

KEYWORDS

Business Process Redesign, business processes, evaluation, representation, modelling.

INTRODUCTION

The emergence of Business Process Redesign (BPR) stems from the need to be adaptable to the evolving organizational change by applying various techniques and approaches towards modifying the process design, depending on the feedback of the process run-time, and/or the performance attributes (Tsakalidis et al., 2019a). The need to systematically evaluate the redesign capability of business processes (BPs) has led to approaches [e.g. (Vanwersch et al., 2016)] that admittedly constitute useful supportive tools for the developers of new process improvement methods, nevertheless, they require process feedback, since they are conducted at runtime. A novel approach (Tsakalidis et al., 2019b) introduces an assessment mechanism for measuring the redesign capability of a BP model prior to implementation, through the evaluation of critical model characteristics (model type, complexity, normalization and optimization capability). This research work looks forward to BPR through data-centric workflow optimization. The feasible input models will be embedded - at a later stage - to an optimization framework, based on transforming a BPMN model to a Directed Acyclic Graph (DAG) and applying established optimization algorithms to the DAG. For the assessment of BPR capability or implementation, there is an abundance of modelling techniques that capture different BP aspects depending on scope (Aldin and de Cesare, 2011). In this paper a fitting representation approach is presented for: (a) facilitating the calculation of complexity metrics and redesign capability of candidate BP models in (Tsakalidis et al., 2019b) and (b) supporting the cost-based optimization technique in (Gounaris, 2016) and (Kougka et al., 2020).

A PROPOSED REPRESENTATION METHOD

The aim of the representation is to capture, visualize and express a BP model in a quantitative way that allows: (a) the evaluation of input models in terms of redesign capacity, and (b) the optimization of feasible input models using cost-based redesign techniques. To achieve the aim, the proposed approach needs to:

1. Provide the visual representation through an extensively used modelling technique,
2. Express the elements of the process using mathematical parameters,
3. Express the input model constraints for evaluating the redesign heuristics applicability.

For applying the proposed representation on a case study, consider a hardware retailer preparing basic steps for the shipment of the ordered goods to the customer. The scenario comes from (Object Management Group (OMG), 2010) and Figure 1 shows the related BP model.

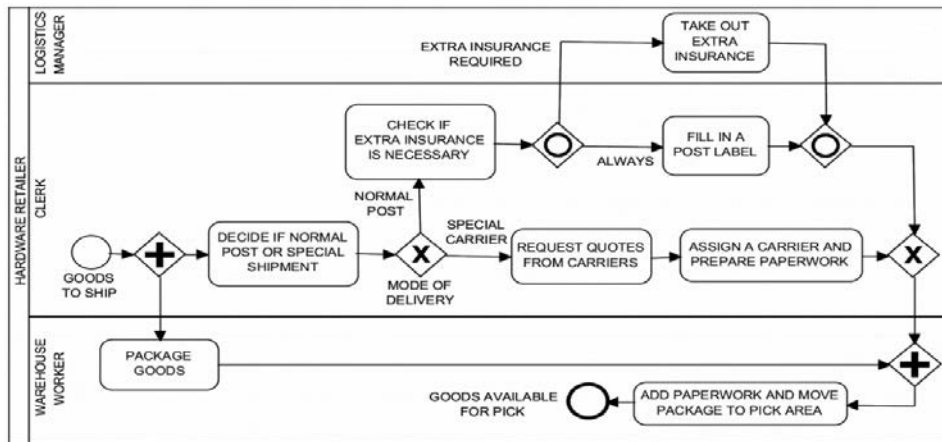


Figure 1. Shipment Process of a Hardware Retailer (Object Management Group (OMG), 2010)

Representation Requirements

The input model should fulfill specific requirements:

Requirement 1: Be modelled in BPMN 2.0 modelling technique and of appropriate model type. BPMN 2.0 is the established standard for designing workflows (Yousfi et al., 2016) and is extensively adopted by process analysts and developers alike. There are three model types within an end-to-end BPMN model, namely processes, choreographies and collaborations (Object Management Group, (OMG), 2011). The three basic types of processes are: (a) private non-executable BPs, (b) private executable BPs, and (c) public processes. The authors consider that the input model should be a private BP, either executable or non-executable, due to the fact that this model type is designed to document the process behavior of the BP. Moreover, it should be consisted of the most commonly used elements for depicting the model's control flow, i.e. activities (atomic and collapsed subprocesses), events (start, intermediate, end events), gateways (splitting and joining nodes of XOR, OR, AND gateways) and sequence flows. These requirements are essential for the input model to be compatible to the redesign technique. The model in Figure 1 fulfills these requirements due to the fact that it is a BPMN 2.0 model, it is a private non-executable BP and it is consisted of elements (start and end events, AND, XOR and OR gateways and tasks) out of a subset of the most commonly used elements.

Table 1. Statistical Metadata

TASK	Execution Time (sec)	Selectivity
DECIDE IF NORMAL POST OR SPECIAL SHIPMENT	60	1
CHECK IF EXTRA INSURANCE IS NECESSARY	60	0.8
TAKE OUT EXTRA INSURANCE	900	0.16
FILL IN A POST LABEL	500	0.8
REQUEST QUOTES FROM CARRIERS	1300	0.2
ASSIGN A CARRIER AND PREPARE PAPERWORK	500	0.2
PACKAGE GOODS	900	1
ADD PAPERWORK AND MOVE PACKAGE TO PICK AREA	900	1

Requirement 2: Include the necessary information (Sets of Monetary/Time Cost and Selectivity per atomic Activity) for measuring performance. For the particular case study, statistical metadata (Table 1) are imported from (Cimino and Vaglini, 2014), in which the authors carried out both a single-valued simulation of 100 instances and an interval-valued simulation on the shipment process (Object Management Group (OMG), 2010) in Figure 1, by using intervals on some tasks and resources. This information is essential for measuring the improvement of performance criteria between the AS-IS and TO-BE model.

Requirement 3: Include all model constraints that depict the execution logic and reduce the capability of activities to be resequenced, put in parallel, etc. To accomplish this, the authors of this paper use a constraints subset (init, last, chain precedence and precedence) from the research field of declarative BP modelling (Haisjackl et al., 2013), and a novel constraints subset (coexistence, xor_existence, or_existence, neg_coexistence) developed for depicting implicit constraints. In brief, coexistence and neg_coexistence constraints account for tasks set in different branches of an AND gateway constraint expresses the incapability of two tasks to be put in different branches of an AND gateway. The xor_existence and or_existence constraints denote that two tasks are set in different branches of a XOR or OR gateway accordingly. This information is essential for measuring the applicability of redesign heuristics, with the use of

corresponding metrics. For the case study, there are no explicit constraints provided by the analyst and the authors introduce three indicative ones:

1. The task “ADD PAPERWORK AND MOVE PACKAGE TO PICK AREA” is the last task to be executed before the end event “GOODS AVAILABLE FOR PICK”.
2. The task “CHECK IF EXTRA INSURANCE IS NECESSARY” directly precedes task “TAKE OUT EXTRA INSURANCE”.
3. The task “REQUEST QUOTES FROM CARRIERS” directly precedes task “ASSIGN A CARRIER AND PREPARE PAPERWORK”.

Model Representation

The proposed approach is a hybrid BP representation method. According to Andaloussi et al. (2018) hybrid process model representations are categorized into: (a) approaches that combine a graphical model with textual annotations [e.g. (Pinggera et al., 2012)] and (b) hybrid representations that combine two or more notations into a single artifact [e.g. (Slaats et al., 2016)]. The proposed representation falls naturally under the latter category, due to the fact that it is comprised of the established BPMN notation and a graph-based notation, that is based on (Ouyang et al., 2006) approach and is modulated to previous cost-based optimization approaches [(Gounaris, 2016), (Kougka et al., 2020)]. The Business Process Diagram (BPD) is defined as the following five-tuple graph:

Definition 1. (BPD-Graph) - Let $\mathbf{BPD} = (\mathbf{O}, \mathbf{F}, \mathbf{P}, \mathbf{S}, \mathbf{C})$ be a graph with

- \mathbf{O} — the set of nodes (objects) in the BPD-Graph.
- \mathbf{F} — the set of edges (Flows) in the BPD-Graph.
- \mathbf{P} — the set of performance attributes of particular nodes (objects \mathbf{O}^A) in the BPD-Graph.
- \mathbf{S} — the set of statistical metadata (selectivity) of particular nodes (objects \mathbf{O}^A) in the BPD-Graph.
- \mathbf{C} — the set of constraints between particular nodes (objects) in the BPD-Graph.

In order to distinguish the different sets (nodes, edges, attributes and constraints) in a BPD-Graph, some additional notations are required. In particular:

- Set \mathbf{O} further includes \mathbf{O}^P , which is partitioned into the disjoint subsets of pools \mathbf{O}_{Po}^P and Lanes \mathbf{O}_L^P .
- Set \mathbf{F} is restricted to \mathbf{F}^S , which is the set of sequence flows-edges.
- Set \mathbf{P} is partitioned into the disjoint subsets \mathbf{P}^T and \mathbf{P}^C , which stand for execution time and monetary cost per \mathbf{O}^A object respectively.
- Set \mathbf{C} is partitioned into the disjoint subsets $\mathbf{C}^I, \mathbf{C}^L, \mathbf{C}^P, \mathbf{C}^{CP}, \mathbf{C}^{CO}, \mathbf{C}^{OR}, \mathbf{C}^{XR}$ and \mathbf{C}^{NC} , which stand for init, last, precedence, chain precedence, coexistence, or_existence, xor_existence and neg_coexistence constraints respectively.

Table 2 Performance and Selectivity Labels

TASK	TASK LABEL	TIME LABEL	VALUE (sec)	SELECTIVITY LABEL	VALUE (ratio)
DECIDE IF NORMAL POST OR SPECIAL SHIPMENT	\mathbf{T}_1	\mathbf{P}_1^T	20	\mathbf{S}_1	1
CHECK IF EXTRA INSURANCE IS NECESSARY	\mathbf{T}_2	\mathbf{P}_2^T	40	\mathbf{S}_2	0.8
TAKE OUT EXTRA INSURANCE	\mathbf{T}_3	\mathbf{P}_3^T	120	\mathbf{S}_3	0.3
FILL IN A POST LABEL	\mathbf{T}_4	\mathbf{P}_4^T	60	\mathbf{S}_4	0.6
REQUEST QUOTES FROM CARRIERS	\mathbf{T}_5	\mathbf{P}_5^T	180	\mathbf{S}_5	0.2
ASSIGN A CARRIER AND PREPARE PAPERWORK	\mathbf{T}_6	\mathbf{P}_6^T	600	\mathbf{S}_6	0.2
PACKAGE GOODS	\mathbf{T}_7	\mathbf{P}_7^T	420	\mathbf{S}_7	1
ADD PAPERWORK AND MOVE PACKAGE TO PICK AREA	\mathbf{T}_8	\mathbf{P}_8^T	240	\mathbf{S}_8	1

The representation methodology is based on the following steps:

1. Assign labels to the activities (tasks), events, gateway elements, participants and flows (sequence flows), as shown in Table 2. Follow a top-down approach for gateway branches and first come-first serve for numbering. Create \mathbf{O} ($\mathbf{O}^A, \mathbf{O}^E, \mathbf{O}^G, \mathbf{O}^P$) and \mathbf{F} (\mathbf{F}^S) sets.
2. Assign labels to the performance and selectivity attributes based on Table 1. Create \mathbf{P} and \mathbf{S} sets.
3. Extract the implicit constraints from the BPMN model and assign labels to both the implicit and given explicit constraints.

The set of activities is $\mathbf{O}^A = \{\mathbf{T}_1, \mathbf{T}_2, \mathbf{T}_3, \mathbf{T}_4, \mathbf{T}_5, \mathbf{T}_6, \mathbf{T}_7, \mathbf{T}_8\}$. The set of events is $\mathbf{O}^E = \mathbf{O}_S^E \cup \mathbf{O}_I^E \cup \mathbf{O}_E^E \Rightarrow \mathbf{O}^E = \{\mathbf{Str1}, \mathbf{End1}\}$, where $\mathbf{O}_S^E = \{\mathbf{Str1}\}, \mathbf{O}_I^E = \emptyset, \mathbf{O}_E^E = \{\mathbf{End1}\}$ and Str1, End1 stand for “GOODS TO SHIP” and “GOODS AVAILABLE FOR PICK” respectively. The gateway elements do not possess a descriptive label (except from “MODE OF DELIVERY”) and the set of gateways is: $\mathbf{O}^G = \mathbf{O}_{S,X}^G \cup \mathbf{O}_{S,O}^G \cup \mathbf{O}_{S,A}^G \cup \mathbf{O}_{J,X}^G \cup \mathbf{O}_{J,O}^G \cup \mathbf{O}_{J,A}^G \Rightarrow \mathbf{O}^G =$

{Xors1, Ors1, Ands1, Xorj1, Orj1, Andj1}, where $O_{S,X}^G = \{Xors1\}$, $O_{S,O}^G = \{Ors1\}$, $O_{S,A}^G = \{Ands1\}$, $O_{j,X}^G = \{Xorj1\}$, $O_{j,O}^G = \{Orj1\}$, $O_{j,A}^G = \{Andj1\}$. The set of participants is $O^P = O_{P_o}^P \cup O_L^P \Rightarrow O^P = \{\mathbf{Pool1}, \mathbf{Lane1}, \mathbf{Lane2}, \mathbf{Lane3}\}$, where $O_{P_o}^P = \{\mathbf{Pool1}\}$, $O_L^P = \{\mathbf{Lane1}, \mathbf{Lane2}, \mathbf{Lane3}\}$ and Pool1, Lane1, Lane2 and Lane3 labels stand for "HARDWARE RETAILER", "LOGISTICS MANAGER", "CLERK" and "WAREHOUSE WORKER" respectively.

The set of sequence flows is: $F = \{F_1^S, F_2^S, F_3^S, F_4^S, F_5^S, F_6^S, F_7^S, F_8^S, F_9^S, F_{10}^S, F_{11}^S, F_{12}^S, F_{13}^S, F_{14}^S, F_{15}^S, F_{16}^S, F_{17}^S, F_{18}^S\}$. The set of performance attributes is $P = P^T \cup P^C \Rightarrow P = \{P_1^T, P_2^T, P_3^T, P_4^T, P_5^T, P_6^T, P_7^T, P_8^T\}$ since $P^T = \emptyset$. The set of selectivities is: $S = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8\}$.

The implicit constraints are extracted and labelled in Table 3, while explicit ones are presented in Table 4.

Table 3 Implicit Constraints

IMPLICIT CONSTRAINT	LABEL	IMPLICIT CONSTRAINT	LABEL	IMPLICIT CONSTRAINT	LABEL
or_existence (T ₃ , T ₄)	C_1^{OR}	xor_existence (T ₃ , T ₆)	C_4^{XR}	coexistence (T ₂ , T ₇)	C_2^{CO}
xor_existence (T ₂ , T ₅)	C_1^{XR}	xor_existence (T ₄ , T ₅)	C_5^{XR}	coexistence (T ₃ , T ₇)	C_3^{CO}
xor_existence (T ₂ , T ₆)	C_2^{XR}	xor_existence (T ₄ , T ₆)	C_6^{XR}	coexistence (T ₄ , T ₇)	C_4^{CO}
xor_existence (T ₃ , T ₅)	C_3^{XR}	coexistence (T ₁ , T ₇)	C_1^{CO}	coexistence (T ₅ , T ₇)	C_5^{CO}
				coexistence (T ₆ , T ₇)	C_6^{CO}

Table 4 Explicit Constraints

EXPLICIT CONSTRAINT	EXPLICIT CONSTRAINT DESCRIPTION	LABEL
last(T ₈)	The task "ADD PAPERWORK AND MOVE PACKAGE TO PICK AREA" is the last task to be executed before the end event "GOODS AVAILABLE FOR PICK".	C_1^L
chain_precedence (T ₂ , T ₃)	The task "CHECK IF EXTRA INSURANCE IS NECESSARY" directly precedes the task "TAKE OUT EXTRA INSURANCE".	C_1^{CP}
chain_precedence (T ₅ , T ₆)	The task "REQUEST QUOTES FROM CARRIERS" directly precedes the task "ASSIGN A CARRIER AND PREPARE PAPERWORK".	C_2^{CP}

The set of constraints (Explicit and Implicit) is: $C = C^L \cup C^{CP} \cup C^{OR} \cup C^{XR} \cup C^{CO} \Rightarrow C = \{C_1^L, C_1^{CP}, C_2^{CP}, C_1^{OR}, C_1^{XR}, C_2^{XR}, C_3^{XR}, C_4^{XR}, C_5^{XR}, C_6^{XR}, C_1^{CO}, C_2^{CO}, C_3^{CO}, C_4^{CO}, C_5^{CO}, C_6^{CO}\}$.

APPLICABILITY OF THE PROPOSED REPRESENTATION

This section highlights the way in which the proposed representation facilitates the calculation of complexity metrics and the degree of redesign heuristics applicability. The calculation of particular complexity metrics and further evaluation bears substantial benefits, primarily in enhancing the correctness, maintainability and understandability of BP models (Cardoso et al., 2006) and can also prove to be a redesign decision point. In previously published work (Fotoglou et al., 2020) the authors selected three established and representative complexity metrics (NOAJ, CFC and CNC), that primarily focus on size, control-flow and structuredness of a process model. And manually calculated the metrics through their equations. For example, calculating the metric values in Fotoglou et al. (2020) approach for the case study in Figure 1, results in:

- $NOAJ = 8$ (tasks) + 3 (gateway splits) + 3 (gateway joints) \Rightarrow **NOAJ = 14**.
- $CFC_{XOR-split} = \text{fan-out} \Rightarrow CFC_{XOR-split} = 1$ (XOR gateway "MODE OF DELIVERY")
 $CFC_{OR-split} = 2^{2-1} \Rightarrow CFC_{OR-split} = 2$ (OR gateway for extra insurance)
 $CFC_{AND-split} = 1$ (AND gateway)

$$CFC_{abs}(P) = \left(\sum_{i \in (XOR\text{-splits of } P)} CFC_{XOR-split}^i \right) + \left(\sum_{j \in (OR\text{-splits of } P)} CFC_{OR-split}^j \right) + \left(\sum_{k \in (AND\text{-splits of } P)} CFC_{AND-split}^k \right)$$

$$\Rightarrow CFC_{abs}(P) = 1 + 2^{2-1} + 1 \Rightarrow \mathbf{CFC_{abs}(P) = 4}$$

- $CNC = \text{number of arcs} / \text{number of activities joints and splits} \Rightarrow CNC = 18 / 14 \Rightarrow \mathbf{CNC = 1,29}$.

The calculation is based on counting the corresponding elements from the BPMN model, which can be error-prone and time consuming. On the other hand, using the proposed representation at this – early to the BPR – stage renders the calculation of the same complexity metrics a more straightforward and simple procedure:

- $NOAJ = |O^A \cup O^G| \Rightarrow \mathbf{NOAJ = 14}$.
- $CFC_{XOR-split} = \text{fan-out} \Rightarrow CFC_{XOR-split} = 1$ (for $O_{S,X}^G = \{Xors1\}$), $CFC_{OR-split} = 2^{2-1} \Rightarrow CFC_{OR-split} = 2$ (for $O_{S,O}^G = \{Ors1\}$), $CFC_{AND-split} = 1$ (for $O_{S,A}^G = \{Ands1\}$), which entails that $\mathbf{CFC_{abs}(P) = 4}$.
- $CNC = |F| / |O^A \cup O^G| \Rightarrow \mathbf{CNC = 1,29}$.

DISCUSSION AND CONCLUSIONS

This paper presented a novel representation method that combines a visual perspective, through the established BPMN 2.0 standard and a quantitative graph-based structure, that incorporates (a) the necessary elements for capturing the execution logic (b) the information for measuring performance and (c) the model constraints that affect redesign. The representation is amenable to cost-based optimization techniques and also supports the evaluation of BPs towards the BPR practice. The latter is demonstrated through the representation of a typical BP model in which the calculation of critical complexity indicators is significantly simpler and straightforward. Another contribution of the representation method is that it incorporates a gamut of model constraints that originate from declarative BP modelling, along with four novel constraint types introduced by the authors. The applying constraints affect the applicability of redesign heuristics (e.g. resequencing, parallelism and knockout) that resemble state-of-the-art algorithms developed for data-centric workflow optimization. As a future work, the representation will be embedded to the transformation phase of BPMN models to DAGs, prior to optimization. The mapping of BPMN elements to the corresponding DAG symbols will be facilitated by the graph-based structure of the representation and the authors intend to automate this procedure.

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A Questionnaire Based on the SERVQUAL Instrument to Reduce the Digital Divide of Business Processes

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Abstract

The digital divide is affecting businesses more and more, and most importantly, it has a direct impact on business processes. Although the literature on the digital divide is constantly being enriched, it is nevertheless common to focus on the analysis of the Digital Divide in terms of the company's behavior with society itself and not with business processes. After all, in the past, important trends, such as the Business Processes Automation and the Business Processes Reengineering have highlighted the need for business compliance in the modern business environment. It is now becoming increasingly clear that the trend of Digital Transformation is bringing businesses to a new great challenge related to the integration of the technology and skills of human resources. The main research question is related to whether the CEOs of the companies realize the existence of the digital divide in the individual processes of their companies. Through the SERVQUAL instrument it is possible to ascertain the existence of a discrepancy between the perception and the expectation of the CEOs in a series of issues. The current work attempts to present a questionnaire that will be based on SERVQUAL instrument, in order to make a measurement between the perception and the expectation of CEOs from the introduction of data to reduce the digital divide in the companies that are employed. The research goals focus mainly on highlighting the factors that contribute to the creation of the digital divide. These factors are formed through three sub-categories related to technological modernization, the existence of employee skills and technological change and organizational behavior of companies. With the contribution of 26 questions, which are structured in five main axes of the SERVQUAL instrument, it is expected to highlight the areas that need changes and interventions in business processes, with special emphasis on administrative department.

KEYWORDS

Digital Divide, Digital Inequalities, Business Process Reengineering, Digital Transformation, SERVQUAL Instrument

INTRODUCTION

Modern businesses are constantly confronted with the effects of technology. In addition to the positive impact of technology on the operation of businesses, the problems that arise should be taken into account. Regardless of the division of companies according to their size (large, medium-sized and small) the integration of technology creates a number of problems both in daily operation and in decision making. The non-adaptation of companies to technological changes defines the digital divide. These changes are more related to sub-sectors, which are either related to internal business processes or defined by business activities in relation to customers (mainly forms B2B and B2C). The negative impact of the digital divide is often measured and it is costed in monetary units resulting from the loss of either the business' adaptation to the new data or the lack of competitiveness that it is observed. However, in any case it is crucial to be underlined the perspective of business executives on whether they believe that a business may already have digital divide and whether they are perceived by the executives of the respective companies.

THE MEANING OF DIGITAL DIVIDE

The existence of the digital divide is created by the discrepancy that it is observed in individual factors of integration of technology in the daily operation of the company. Therefore, the non-existence of a digital divide is associated with the full and ever- expanding integration of technology in business change, while at the same time individual factors can fully and efficiently utilize technology for the benefit of the day-to-day business processes.

However, the key question that is often asked in the scientific community is related to the existence of companies that are fully adapted to technological changes in both tangible and intangible level, i.e. they do not present elements of the digital divide. In practice, the existence of such companies is practically difficult and perhaps unlikely. No matter how technologically advanced the companies are, there are always deficiencies which are identified in individual factors,

such as human resources. After all, this makes sense as the more employees there are in a company, the greater the diversity of personalities that make up the individual departments. It is therefore difficult for a company to fully adapt to technological developments.

In this context, the digital divide is identified, i.e. a multifaceted equation of individual factors that characterize the deviation from modern forms of convergence with technology. The digital divide according to the literature can be divided into three stages. The first stage is related to the Economic Gap, the second stage with the Usability Divide and thus of individual skills shortage, and finally the third stage is related to the divide that is observed in the operations of the businesses and is focused on the empowerment and motivation of the employees (Nielsen, 2006; Fidan, 2017).

First Stage of Digital Divide

In the first stage of the digital divide, there are significant discrepancies in the companies' budgets for their technological modernization. Technological modernization does not have to come only within the production line but also in the support services. It is also important to note that for most companies, the divide lies in the inefficiency of administrative services. Many companies do not have the necessary up-to-date equipment while software incompatibilities are visible in operational issues.

The first stage of divide was created as early as the mid-1980s. The Business Process Automation (BPA) process was successful for all businesses as they were called upon to introduce the concept of information technology and automation into the business environment. Then, 10 years later companies were called upon to transform their organizational structure to a significant degree through the Business Process Re-engineering (BPR). The transformation, in addition to organizational changes involved the adoption of technology through modern computers. The Internet access had to be considered compulsory as even the simplest communications were now made through it (Jones, 2017; Vial, 2019).

The decade of 2010s was decisive for the next phase of the transformation. Bibliographically, this period was considered to be the main reason for the increase of the digital divide in companies. Businesses moved in three directions, those that adopted the technology directly and were considered functional, those that tried with dubious results, and the last ones that failed to follow. To a large extent, the term was recorded as Digital Transformation since the turnover of the most important companies took place mainly through the Internet and mobile applications (Richmond et al., 2017).

Nowadays, the challenges are clearly greater and are integrated not only in the range of activities of a business through the Internet, but mainly in the full operation via the Internet in terms of the services provided. From the simplest services that are integrated in the call centers to the most complex administrative services, such as those of costing, it is important to apply mainly through the Internet with parallel issuance of forms (e.g. e-invoices) with digital signature and parallel information of each ministry.

Second Stage of Digital Divide - Digital Skills

The second level of the digital divide focuses on the lack of skills of Human Resources. The issue of skills is already very important and has been mentioned not only in the literature review but even more so in institutions, such as the European Union and UNESCO. Skills are becoming a major issue as their lack is proven to be an obstacle to the efficiency and effectiveness of employees in companies. Skills are already divided into three main categories, Hard Skills (including formal education studies), Soft Skills (including skills that fit everyone's personality and are independent of work, such as time management and communication skills), and finally Digital Skills (including skills related to managing of new digital technology).

The European Union updates the Digital Competence (DigComp) model in version 2.1 and it has made Digital Skills a major criterion for every employee. The 2020 updated report of "Dig Comp at Work" already highlights the concept of sustainable employment at work, as well as education through digital skills. Digital education is already a very important element in highlighting digital skills in business and in the concepts of sustainable employment and entrepreneurship (Kluzer et al., 2020).

In addition, the scientists who dealt with the concept of digital skills in determining the digital divide were also important. According to the literature, skills in general (including all three categories) determine by 65% the digital divide and much more the lack of digital skills that by 70% of the above percentage, create a negative relationship between the gap and efficiency. Practically, the lack of digital skills in the workforce and staff of companies affects by 45.5% the increase of the digital divide as a whole **Invalid source specified..**

Third Stage of Digital Divide - Organizational Structure and Change Management

The structure of the business is often the main and basic reason for creating operational problems at the organizational level. Changes are the main reason for resistance. In modern business, changes are usually focused on the introduction of technology in the individual departments. The main reasons that create problems and are related to the changes are the lack of technological background, the lack of education, the lack of skills, as well as the fear of losing one's job. Employees not always be positively adjacent to such changes as their daily lives disrupted. In any case, the digital divide is related to the unorthodox introduction of change and especially of technological change. Modern business schemes and data require flexible employees who are very positive about changes and can adapt to modern technological needs. In any case, the above are important elements on the basis of which the digital divide is further strengthened.

METHODOLOGY FOR CREATING A QUESTIONNAIRE

The questionnaire below is based on the SERVQUAL instrument, a tool that focuses on measuring service quality. The specific tool and methodology are based on the measurement of the gap that is created between the expectations and the perceptions of the respondents for 5 specific dimensions and specifically for the dimensions of Reliability, Assurance, Tangibles, Empathy, and finally Responsiveness. Practically, each of the sub-stages described above will be listed in the special part of the questionnaire. In the questionnaire there are the General and the Special part. In the General Part, data will be recorded related to each company and some general-demographic characteristics, which will be analyzed in each case by methods of descriptive statistics, while in the special part the following questions will be quoted in duplicate, one for perceptions and one for expectations (Parasuraman et al., 2001).

Methodologically, the SERVQUAL instrument is based on the following mathematical formula (Parasuraman et al., 1988):

$$G_j = \sum_{i=1}^n w_i \cdot (E_{ij} - I_i)$$

G_j measures the digital gap that exists in the services provided by the employees of the Administrative Department of the company from the ideal level

w_i measures the level of importance of the individual variables. In this case all variables participate equally in the final score and therefore the percentage is calculated in advance as 20%

E_{ij} measures the perception of the Business Executive (e.g. CEO) about the existence of the digital divide for the feature i

I_i measures the expectation of the Business Executive (e.g. CEO) for the existence of the digital divide for the feature i

n is related to the total number of quality characteristics

Table 1. Questions of SERVQUAL instrument

No of Question	Questions
Dimension: Reliability – Related to 2 nd Stage of Digital Divide – Weight Factor:20%	
Ri1	The employees of the Administrative Department (Dept.) possess the digital skills in order to perform their work in relation to the software and apps of the company.
Ri2	The employees of the Administrative Dept. possess the digital skills in order to perform their work remotely using special software (e.g. Teamviewer, Webex, etc).
Ri3	The employees of the Administrative Dept. need constant guidance in order to cooperate with the use of special software remotely
Ri4	The employees of the Administrative Dept. effectively solve problems related to their computer or software and that may arise during their work
Ri5	The employees of the Administrative Dept. can keep schedules and deliver the work packages on time
Ri6	The employees of the Administrative Dept. are accurate in their work and do not need guidance
Ri7	The employees of the Administrative Dept., despite the existence of the necessary hard skills, often need help in the use of the software.
Ri8	The employees of the Administrative Dept. need constant guidance when working on ordinary projects
Dimension: Assurance – Related to 2 nd Stage of Digital Divide – Weight Factor:20%	
As1	The employees of the Administrative Dept. have the necessary skills to serve their colleagues

As2	The employees of the Administrative Dept. have the necessary skills to make the customers of the company feel safe for their choice
As3	The employees of the Administrative Dept. are considered cooperative by their colleagues
As4	The employees of the Administrative Dept. have the necessary guidance (active HR support practices, coaching, mentoring) in order to successfully exercise their responsibilities. Dimension: Tangibles – Related to 1 st Stage of Digital Divide – Weight Factor:20%
Ta1	The electronic equipment of the office of the Administrative Dept. (including computers, servers, copiers, etc.) is considered to be fully updated in terms of the best technology
Ta2	The electronic equipment of the office of the Administrative Dept. (including computers, servers, copiers, etc.) is considered to be very fast in terms of speed and processing
Ta3	The electronic equipment of the office of the Administrative Dept. (including computers, servers, copiers, etc.) is considered to be reliable without any delays in the work
Ta4	The electronic equipment of the office of the Administrative Dept. (including computers, servers, copiers, etc.) is considered fully serves the requirements of the work it performs Dimension: Empathy – Related to 2 nd Stage of Digital Divide – Weight Factor:20%
Em1	The employees of the Administrative Dept. have the skills to provide personalized support to their colleagues who need it within the scope of their job responsibilities.
Em2	The employees of the Administrative Dept. have the skills to provide personalized support to clients who need it within the scope of their job responsibilities.
Em3	The employees of the Administrative Dept. have the skills to understand the needs of their clients
Em4	The employees of the Administrative Dept. observe their working hours
Em5	The employees of the Administrative Dept. understand the interests of customers and do not conflict with them Dimension: Responsiveness – Related to 3 rd Stage of Digital Divide – Weight Factor:20%
Re1	Heads of Dept. are willing to inform their subordinates about upcoming changes
Re2	Heads of Dept. are willing to make changes in their departments that will improve the working conditions of their subordinates
Re3	Heads of Dept. are willing to implement necessary and "tough" changes that will benefit the company
Re4	Heads of Dept. are willing to propose changes in the organizational structure of the department
Re5	Heads of Dept. are willing to support management proposals that will change the organization of work

The basic assumptions of the SERVQUAL instrument reveal that the researcher should also decide whether the concept of the Administrative Sector should remain or be differentiated on the basis of the structure of the company. In addition, it is important that this questionnaire should be answered by a CEO of the company who has an idea of the individual departments. At this point it should be emphasized an important feature of this questionnaire, related to the submission of 26 questions instead of 22 that had the original SERVQUAL Instrument. In the literature there are many reports on the differentiation of individual questions into specific dimensions with particular emphasis on the Responsiveness and Reliability dimension. Thus, following the practice, three more questions were added in relation to the original questionnaire in the Reliability dimension and one in the Responsiveness dimension, in order to include modern visual-practices that integrate modern technology in the work environment. Also, it is important to emphasize that this questionnaire utilizes all three sub-stages as presented above, with particular emphasis on the second stage that participates by 60% in the final result, while the other two by 20% each (Soutar and McNeil, 1996). Finally, it is suggested to list the individual questions in the following format. This will make it easier for the respondent to understand that the same question will be answered separately based on their perception and expectation on a 5-point Likert scale.

Table 2 Questions Table Format

	Perceptions						Expectations						
	Question 1,2,3 etc.						Question 1,2,3 etc.						
Strongly Disagree	1	2	3	4	5	Strongly Agree	Strongly Disagree	1	2	3	4	5	Strongly Agree

Last but not least, it is extremely important to be emphasized that this questionnaire will be more supportively to the respective CEO. This will happen, as it will help him not only to identify the existence of the digital divide, but also the individual sub-stage in which it is located. Then, it will have to adopt modern strategies that are specific to the sector, where the divide occurs, in order to improve the individual processes. The emergence of these strategies is noted in the literature and can be taken, for example, actions related to individual training of employees to improve their skills, to adopt changes at the operational level in order to gain flexibility in decision-making or to modernize the technological equipment.

CONCLUSIONS

The digital divide is one of the most pressing issues in the modern business environment. Technology is constantly evolving with the consequence that there are not enough time and resources for businesses to follow this pace. As a result, business productivity and efficiency are declining, with the consequent competitive pressures of the external environment constantly increasing. In this context, there are three main pillars that could justify the digital divide. The first is purely related to hardware-software, the second is purely related to the skills of the human resources, and the third is focused on Change Management and the Organizational Environment. In this paper, a questionnaire based on the SERVQUAL instrument was presented in order to highlight the area that each company is facing problems through key questions. With the help of the respective researcher, the respective executive of the company is given the opportunity to identify the areas, where the company needs empowerment in order to reduce the digital divide and improve in terms of competitiveness and efficiency.

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Digital transformation effectiveness evaluation in Greek service SMEs using an ordinal regression analysis approach

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Abstract

Digital transformation has been one of the most debated topics in business in the last decade. It is a systemic way for organisations to leverage new digital technologies in order to radically improve operations, performance, safety, and reduce costs. Focusing on the service industries in developing economies, digital transformation has a major role and the further investigation of its drivers and outcomes is significantly important. The digital transformation journey has a great contribution to the service organisation's success. The main purpose of this study is to evaluate the effectiveness of digital transformation in Greek small and medium service enterprises (SMEs). For this purpose, the drivers of digital transformation were explored and correlated with the organisational performance, as an outcome, of the service organisations through an ordinal regression analysis model. This model adopts a mathematical programming approach so that it estimates the efficiency of this process. For the purpose of the survey, a structured questionnaire was developed, including variables associated with all the stages of digital transformation. These variables were measured on a 5point Likert-type scale. The sample of the survey consists of 48 professionals who are involved in digital transformation initiatives. The main results of the research methodology include the estimated contribution of each factor to the overall firm performance of the Greek service SMEs studied.

KEYWORDS

Digital Transformation, Organisational Performance, Digital Strategy, Ordinal Regression Analysis

INTRODUCTION

In the digital age, service organisations bear with a fast-changing business environment, volatility and uncertainty. Rapid changes in technology, demand, regulations and competition force organisations to become more agile and adapt to this situation (Kitsios and Zopounidis, 2007). New digital technologies bring forward a deep transformation which needs to be performed by organisation, initially in a strategic context. Digital transformation itself concurrently affects a wide range of areas in the organisational context. As a result managers and decision-makers need to understand the drivers digital transformation and their relationship with the outcomes of their organisation (Berghaus and Back, 2016). Understanding the driving factors and performance impact of digital transformation is critical to the service organisations contributing towards its success. As digital transformation increases, organisations are capable of accomplishing improved customer loyalty, better customization, increased customer satisfaction and decreased costs (Chen et al. 2016; Nwankpa and Roumani, 2016). Prior studies suggest that digital transformation could positively influence firm performance (Chen et al., 2016; Mitroulis and Kitsios, 2019a; Mitroulis and Kitsios, 2019b; Nwankpa and Roumani, 2016).

The aim of this study is to evaluate the effectiveness of digital transformation in Greek small and medium service enterprises (SMEs). For this purpose, the drivers of digital transformation were explored and correlated with the organisational performance, as an outcome, of 48 service organisations through an ordinal regression analysis model. Data were collected addressing a questionnaire to professionals involved in digital transformation initiatives.

The rest of the study is organised as follows: Section 2 reviews and discusses prior researches related to digital transformation and its outcomes, gathering the needed literature. Section 3 describes the research methodology and the data analysis. Section 4 presents the attained results. Finally, Section 5 shows the conclusions of the study and proposes some future research directions.

LITERATURE REVIEW

Although digital transformation is critical for the success of organisations, there is still no commonly accepted definition. However, there are the three main pillars of digital transformation which lay on value creation, processes optimization affecting customer experience and organisational capabilities which support the overall transformation initiative. Even though the implementation of digital technologies in the organisational context is considered to be part of the digital business transformation initiative, it has a high impact on value creation for all stakeholders and business itself (Kitsios and Kamariotou, 2019; Kitsios and Kamariotou, 2020; Kitsios et al., 2019a; Kitsios et al., 2019b). Prior studies point out the importance of digital transformation success factors (Henriette et al., 2016). Moreover, Mhlungu et al. (2019) highlight the existence of four dimensions of underlying factors of a successful digital transformation initiative. These dimensions are: customer centricity, governance, innovation, resource attainment, and strategy. In the same direction, digital transformation assessments evaluate the drivers of digital transformation. Additionally, other studies both test and suggest elements related to technology, culture, people, customers, processes, innovation, strategy, governance, products/services (Berghaus and Back, 2016; Hess et al., 2016; Matt et al., 2015; Schumacher et al. 2016; von Leipzig et al., 2017). In the current study, these dimensions are considered as drivers of digital transformation.

Many prior researches in the field of "digital transformation" have studied the measurement of organisational performance (Vial, 2019). Chen et al. (2016) found a both positive and significant relationship between digitalized processes and performance outcomes. Nwankpa and Roumani (2016) suggested that digital transformation positively influences innovation and organisational performance of organisations. Some of the implemented performance dimensions are profitability, sales growth, innovation, product/service quality improvement, cost reduction, revenue growth, operational efficiency, improved customer satisfaction and retention, improved ROI, market share growth and improved sales revenue (Chen et al., 2016; Kitsios and Grigoroudis, 2014; Kitsios and Grigoroudis, 2020; Mitroulis and Kitsios, 2019a; Nwankpa and Roumani, 2016). In this study, these dimensions are considered as the outcomes of digital transformation.

METHODOLOGY

Data and Variables

This study gathers the drivers of digital transformation, which been previously proposed in the related literature, leading to 118 factors. These factors were used in order to design a structured questionnaire which was applied to 48 Greek small and medium service enterprises. The research was conducted during March and May 2020 using a Liker-type data collection process. Based on the abovementioned framework, this study analyzes the efficiency of digital transformation processes in the Greek service organisations. For this reason, two sets of variables have been used:

- Drivers: These variables are based on the digital transformation of the organisation and can be considered as the causes of the organisational performance. As presented in Table 1, all variables used in the research are categorized into 14 main groups (Berghaus and Back, 2016; Schumacher et al. 2016; von Leipzig et al., 2017).
- Outcomes: These variables are based on the organisational performance indices. As presented in Table 2 a total of 17 both financial and non-financial ratios are used in this study (Chen et al., 2016; Mitroulis and Kitsios, 2019; Nwankpa and Roumani, 2016).

Table 1 Digital transformation variables (drivers of efficiency)

Dimension	Variables	Dimension	Variables
1. Digital strategy	Organization has a defined digital strategic vision; Employees are aligned with the digital strategic vision...	8. Operations and processes	Process digitization and automation; Flexibility and agility of processes; Operational excellence; Regularly check and optimise core processes...
2. Transformation management	Top management recognizes the importance of digital business; Senior management takes responsibility for digital transformation...	9. Governance	Ensure comprehensive and reliable execution of digital strategy; Everyone has permission to think creatively and innovate;...
3. Organisation	Management structure supporting digital business; Cross-functional collaboration; Defined roles related to digital transformation...	10. Employees and expertise	Have a plan for digital skills, expertise, experience and interest improvement; Personnel dedicated to digital transformation...
4. Technology	IT architecture/systems and new digitalization-based IT systems; Agility of supporting systems...	11. Products and services	Smart products/services; Digitization of product/service offerings; Data analytics deployed for personalized offerings...
5. Culture	Risk-taking; Test & learn and No-blame culture; Customer-centricity...	12. Digital ecosystem	Organization is part of a digital ecosystem; Digitization/integration of vertical/horizontal value chains...
6. Customer experience	Customer benefit from digitization; Personalized digital customer communication; Personalization of products/services...	13. Compliance and cyber security	IT and digital security; IT compliance within organization and towards stakeholders; Up-to-date security systems, standards and practices...
7. Leadership	Leadership team is learning new technologies...	14. Innovation	Capabilities enabling a more agile way of working; Development of new and disruptive business models...

Table 2 Organisation performance variables (efficiency outcomes)

Dimension	Variables	Dimension	Variables
1. Financial performance	Increase of ROI; Increase of sales revenue; Market share growth; Reduction of expense and cost ; Increase of profitability	2. Non-financial performance	Increase of customer satisfaction; Increase of customer loyalty; Increase of responsiveness; Increase of quality assurance; Increase of operational efficiency; Increase of needs understanding for internal and external processes; Increase employee satisfaction; Improvement of new product/service development; Employees' performance; Improved employee's working attitude; Improvement of digital skills and expertise; Increase of employee retention rate

Ordinal Regression Analysis

The applied model is an ordinal regression analysis approach, assuming a set of explanatory and a set of response variables. In particular, given a set of result variables Y_j and a set of driver variables X_i , the main principle of this approach is that the weighted average of the “values” of Y_j can be written as a weighted average of the “values” of X_i , according to the formula:

$$\begin{cases} \sum_{j=1}^m w_j Y_j^* = \sum_{i=1}^n b_i X_i^* \\ \sum_{j=1}^m w_j = \sum_{i=1}^n b_i = 1 \end{cases} \quad (1)$$

where Y_j^* and X_i^* are the value functions of Y_j and X_i , respectively, b_i and w_j are the weight coefficients, n and m are the number of factors. It should be noted that Y_j^* and X_i^* are piecewise linear, monotone value functions, normalized in the interval $[0, 1]$, thus:

$$\begin{cases} y_j^{*1} = 0, \quad y_j^{*a_j} = 1 \text{ for } j = 1, 2, \dots, m \\ x_i^{*1} = 0, \quad x_i^{*a_i} = 1 \text{ for } i = 1, 2, \dots, n \end{cases} \quad (2)$$

where Y_j^{*k} and X_i^{*k} are the values of the y_j^k and x_i^k level, a_j and a_i are the number of scale levels of functions Y_j^* and X_i^* , respectively. The scales a_j and a_i are defined by the analyst and, when necessary, linear interpolation is used in order to calculate in-between values. According to the previous assumptions, and using a goal programming approach, the ordinal regression analysis equation may take the following form (Wagner, 1959; Siskos, 1985):

$$\sum_{j=1}^m w_j Y_j^* = \sum_{i=1}^n b_i X_i^* - \sigma^+ + \sigma^- \quad (3)$$

where σ^+ and σ^- are the overestimation and the underestimation error, respectively.

The parameters of the model may be estimated using linear programming techniques, where the objective is to minimize the sum of errors, subject to the following constraints:

- Equation (3) for each case (in our application for each digital transformation initiative)
- Monotonicity constraints of Y_j^{*k} and X_i^{*k} .
- Normalization constraints of b_i and w_j .
- Non-negative constraints for all the variables of the model.

This model is similar to canonical correlation analysis, under the philosophy of ordinal regression. A detailed presentation of ordinal regression analysis principles, including a discussion about model stability may be found in Grigoroudis and Siskos (2002, 2010).

RESULTS

The most important results of the ordinal regression model refer to the estimation of importance (b_i and w_j) and performance (average of Y_j^{*k} and X_i^{*k}) of the examined variables. These results are normalized in $[0, 1]$ and thus it is easy to identify the strong and weak points of the digital transformation drivers and results. Table 3 presents the weights and the average performance of the main digital transformation dimensions.

Table 3 Weights and average performance of drivers

Dimensions	Weights (%)	Performance (%)
1. Digital strategy	7,78	55,71
2. Transformation management	7,92	58,57
3. Organisation	8,43	67,14
4. Technology	5,66	64,29
5. Customer experience	7,06	80,00
6. Leadership	7,77	67,14
7. Operations and processes	8,41	72,86
8. Governance	7,27	68,57
9. Employees and expertise	8,04	71,43
10. Products and services	7,06	74,29
11. Products and services	5,62	68,57
12. Digital ecosystem	4,95	50,00
13. Compliance and cyber security	6,83	68,57
14. Innovation	7,18	61,43

Table 4 Weights and average performance of outcomes

Dimensions	Weights (%)	Performance (%)
1. Increase of ROI	4,39	64,29
2. Increase of sales revenue	3,85	60,00
3. Market share growth	1,71	58,57
4. Reduction of expense and cost	5,94	68,57
5. Increase of profitability	5,78	71,43
6. Increase of customer satisfaction	5,88	80,00
7. Increase of customer loyalty	4,31	78,57
8. Increase of responsiveness	3,52	78,57
9. Increase of quality assurance	6,67	77,14
10. Increase of operational efficiency	7,96	77,14
11. Increase of needs understanding for internal and external processes	7,92	78,57
12. Increase of employee satisfaction	6,30	82,86
13. Improvement of new product/service development	7,52	77,14
14. Employees' performance	7,64	80,00
15. Improved employee's working attitude	6,06	81,43
16. Improvement of digital skills and expertise	8,25	78,57
17. Increase of employee retention rate	6,30	82,86

As it could be observed, organisation is the most important dimension and to appears to have a performance index close to the average performance indices. On the other hand, digital ecosystem is the dimension with the lowest importance and has the lowest performance among the digital transformation drivers. Likewise, Table 4 shows the weights and the average performance indices of the organisational performance variables. It could be observed that the improvement of skills and expertise is the most important outcome of digital transformation. Furthermore, both the increase of employees satisfaction and employees retention rate share the highest performance rating. Alternatively, market share growth has the lowest importance and average performance indices.

CONCLUSIONS

This research provides results towards a better understand of how organizations tackle their digital transformation, by defining a set of evaluation criteria and examining the connection between drivers and outcomes of digital transformation implementing an ordinal regression analysis. The presented results identify the most important factors related to digital transformation results. For instance, organisation seems to be the most important digital transformation dimension. This category refers to elements such as management structures, cross-functional collaboration, internal roles and tasks related to digital transformation, agile management and prioritization of digital business. Other also important dimensions are "operations and processes", and "employees and expertise" showing that digital transformation initially starts with management, processes digitalization and employees skills and expertise. Regarding the organisational performance dimensions, the most important outputs refers to improved employees skills and expertise, increase of operational efficiency, and increase of needs understanding for internal and external processes. Assessing digital transformation issues is of significant interest to both researchers and practitioners. Realizing the correlation of digital transformation and organisational performance enhances the knowledge of business transformation management. For practitioners, the results of this research might assist managers and decision-makers to better assess the status quo their digital business transformation and improve their digital transformation strategies. Although this research has presented some interesting and useful findings, there were some limitations that need to be considered when reading it. Firstly, the survey data is based exclusively on participant self-assessment, which might be the reason of a certain bias. In order to mitigate such risk, further research could balance this survey with expert evaluations. Moreover, the survey requires respondents to assess their organization, which might be difficult for them. Finally, the survey was conducted in Greece and the questionnaire was presented in Greek language, in the period of Covid-19 (March - May 2020). The designed methodology needs to be applied to more industries and in a different time period in order to provide more reliable results. Future researches could extend the results of this research in order to further enhance digital maturity models and their accuracy.

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Location Based Marketing Survey for Smartphone Users

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Abstract

Digital Transformation of businesses is a beneficial aspect that can provide added value and satisfy customers' desires on the way to the transaction. Such useful strategies are being offered by Location Based Marketing (LBM) which utilize new smartphone capabilities and apply Location based personalized content to improve product and brand awareness. Location Based Services (LBS) are a powerful ally on the way to mobile advertising content, that seems to gain higher attention along with the Internet of Things (IoT). Our research investigates the LBS potential through the eyes of end-users with the assistance of a questionnaire that examines the key roles of user characteristics and how they influence their ability and volition to accept and use Location Based Marketing content and technologies through their smart-devices. Our statistical analysis on the received sample reveals the correlation between individual aspects of user behavior and the concepts of LBM usage on their daily routine. As future work more aspects regarding LBM can be examined.

KEYWORDS

Location Based Marketing, Location Based Services, Technology Acceptance Model, Location Based Mobile Applications, Internet of Things

LITERATURE REVIEW

The Mobile Marketing Association defines Location-Based Marketing (LBM) as "any application, service, or campaign that incorporates the use of geographic location to deliver or enhance the marketing message / service". This definition limits LBM to be part of the Marketing Mix as an enhanced communication channel used by traders to reach customers. LBM took more time to develop than expected due to objections to the use of mobile location, but is now gaining consumer acceptance that is visible on the market from the increasing number of users as well as from revenue, "it seems that for a large number of people, privacy concerns were not able to prevent them from experimenting and adopting this emerging technology" (Haghirian and Madlberger 2005).

Growth has also been delayed because of the lack of profitable business models, but LBM is expected to play an increasingly important role in generating revenue. It is essential that users and businesses are becoming aware of the new technologies that can enhance indoor navigation and also Location Based Marketing propositions for the offline stores (Andreev, Pliskin, and Rafaeli 2012).

In 2011, Shuguoli Li proposed that Location-Based Mobile Marketing can be described as a convergence of three technologies: Location-Based Services, Mobile Marketing and Contextual Marketing. Another definition includes that Mobile Marketing is the most personal form of online marketing that comes with smart-devices (Krumm 2013).

Contextual marketing is a form of targeted advertising using behavior or text the content of which is placed by the user to provide personalized Internet marketing information in real time (Viviand and Léone 2001). In Location Based Services as part of Context-Aware Services, the box refers to spatio-temporal data or metadata.

Misuse of the LBM may lead to claims for a product or service that the advertiser cannot substantiate. Ads and advertisements that incorporate the customer's geographic location may potentially violate advertising rules, standards, and codes of conduct from different jurisdictions (C. Liu et al. 2005). The United Kingdom Advertising Standards Authority (ASA) requires all advertisements to be honest and not misleading, and there are instances of LBA-based advertisements that have been found to be misleading by the ASA (C. Liu et al. 2005).

METHODOLOGY

We created a questionnaire with 24 questions which are relevant to the field of LBM for Smartphone Users. The first 12 are relevant to personal characteristics of the end-user including sex, age, and familiarization with LBM technologies and implementations. Additionally, those questions were structured in the form of a yes and no answer with the exception of a small part where there were multiple choices of relevant companies with LBM utilizations. The next 12 questions are focusing into unveiling 4 different aspects that are relevant to the LBM field such as usability, easiness of use, enjoyability, and security (Krisp 2014). These 4 aspects were investigated with 3 separate questions for each one of them based on previous research that has implemented similar research strategy. Specifically, from the definition of all the different aspects that were adopted from the bibliography, a separation of the later was utilized so that every metric of a different variable could be measure by 3-5 different question for each case (Giovanis, Assimakopoulos, and Sarmaniotis 2018).

Previous scientific researches have utilized the same research model for estimation of the implementation of the prementioned attributes (Giovanis, Assimakopoulos, and Sarmaniotis 2018). The attributes that have been investigated in form of questionnaire are, performance expectancy, effort expectancy, social influence, perceived risk, perceived trust, and innovativeness. Other researchers are using attributes such as opportunity, Usefulness, Ease of Use, Intention to Use, Device Use, in order to gather their data for their research (Haan, Lugtig, and Toepoel 2019). Questionnaire that targets the banking sector and focuses on smartphone users was conducted in Pakistan on 2019 by academics who proved correlations between individual aspects such as perceived usefulness, perceived ease of use, social influence, intention (Akhtar et al. 2019).

The present study measures the acceptance of LBM, was conducted in Thessaloniki during April 2019. The sample was random and included 100 individuals, 48 of which were men and 52 women. The questionnaire was not distributed electronically in order to include individuals that are not experienced with new technologies (G. Z. Liu and Chong 2011). It included demographic questions (1-12) and questions about their knowledge and experience in LBM, and questions (13-24) that were formulated using the TAM method, using the "Perceived Usefulness" criteria, and "Perceived Security & Privacy" to evaluate their view of the LBM, where the 7-point Likert scale was used to measure individuals' agreement-disagreement. On the following table we present the 24 questions based on the Technology Acceptance Model (TAM) that were delivered to 100 individuals for answering (Lu et al. 2003).

Null Hypotheses

From the literature review there are indications that the different aspects of TAM are correlated to one another. Before we investigate the potential correlations, we have built our null hypotheses that can serve this specific purpose.

H1: The gender of the user is not correlated to the ownership of a smartphone.

H2: The gender of the user is not correlated to the often usage of GPS of the smartphone.

H3: The gender of the user is not correlated to the belief that LBM can be useful for products or services promotion.

H4: The gender of the user is not correlated to the fact that the user can locate easily products/services through LBM.

H5: The gender of the user is not correlated to the belief that is pleasant to find fast information for products/services through LBM.

H6: The gender of the user is not correlated to the belief that service providers can collect much information for the user of LBM.

H7: The ownership of a smartphone is not correlated to the use of GPS of the smartphone.

H8: The ownership of a smartphone is not correlated to the belief that LBM can be useful for products or services promotion.

H9: The ownership of a smartphone is not correlated to the fact that the user can locate easily products/services through LBM.

H10: The ownership of a smartphone is not correlated to the belief that is pleasant to find fast information for products/services through LBM.

H11: The ownership of a smartphone is not correlated to the belief that the service providers can collect much information for the user of LBM.

H12: The use of GPS of the smartphone is not correlated to the belief that LBM can be useful for products or services promotion.

H13: The use of GPS of the smartphone is not correlated to the belief that the user can locate easily products/services through LBM.

H14: The use of GPS of the smartphone is not correlated to the belief that is pleasant to find fast information for products/services through LBM.

H15: The use of GPS of the smartphone is not corelated to the belief that the service providers can collect much information for the user of LBM.

H16: The belief that LBM can be useful for products or services promotion is not corelated to the fact that the user can locate easily products/services through LBM.

H17: The belief that LBM can be useful for products or services promotion is not corelated to the belief that is pleasant to find fast information for products/services through LBM.

H18: The belief that LBM can be useful for products or services promotion is not corelated to the belief that service providers can collect much information for the user of LBM.

H19: The user can locate easily products/services through LBM is not corelated is to the belief that pleasant to find fast information for products/services through LBM.

H20: The user can locate easily products/services through LBM is not corelated is to the belief that service providers can collect much information for the user of LBM.

H21: The belief that pleasant to find fast information for products/services through LBM is not corelated to the belief that service providers can collect much information for the user of LBM.

Chi-Square Test Results

We have utilized the Chi-Square Test algorithm that serves the purpose of finding relations between specific categorical attributes. The implementation of the statistical algorithm was performed on SPSS program and we set a threshold of .05 for the p-value where it would diversify the related attributes from the non-related. So those that had value lower than .05 were rejected our null-hypotheses and those with higher percentage were the ones confirmed. Since the null Hypotheses are that the values mentioned are not correlated, the rejected ones are the one that include corelated values.

Table 1. Chi-Square Test 1/3

Hypotheses	H1	H2	H3	H4	H5	H6	H7
p-value	.476	.485	.686	.067	.219	.749	.000
df	1	1	6	6	5	5	1
Pearson Chi-Square Result	.507 Accepted	.488 Accepted	3.933 Accepted	5.164 Rejected	7.022 Accepted	2.682 Accepted	13.534 Rejected

Table 2. Chi-Square Test 2/3

Hypotheses	H8	H9	H10	H11	H12	H13	H14
p-value	.016	.043	.039	.364	.639	.197	.324
df	6	6	5	5	6	6	5
Pearson Chi-Square Result	15.572 Rejected	13.029 Rejected	11.720 Rejected	5.448 Accepted	4.276 Accepted	8.604 Accepted	5.817 Accepted

Table 3. Chi-Square Test 3/3

Hypotheses	H15	H16	H17	H18	H19	H20	H21
p-value	.302	.000	.000	.000	.000	.000	.000
df	5	36	30	30	30	30	25
Pearson Chi-Square Result	6.043 Accepted	241.964 Rejected	158.754 Rejected	191.741 Rejected	205.352 Rejected	158.798 Rejected	196.292 Rejected

For H1-H3 and H5, H6 gender related Hypotheses are not correlated to the rest of the questions investigated in our research which arguably eliminates the suspicions that women are not so familiarized with expertized software such as Location Based Services ones. Apart from the H4 where actually the gender gaps are present and reveals correlation with the easy locate of products services.

From H7-H10 Another potential conclusion from our research is that the ownership of the smartphone does not necessarily means that the end-user is keen on the use of technologies such as the GPS or the Location Based Marketing contents On the H11 we see that LBM users do not believe that application providers can gather significant amount of related data.

From the H12-14 we can see that the use of GPS is correlated to the fact that the users can find easily their products and services with the use of LBM content on their smartphones. On the other side in H15 the use of GPS seems to make pleasant the search of products through LBM, and so the users believe that the LBS carriers can collect much data of their daily use.

On the H16-H18 we find the fact that the belief that LBM is useful is not correlated to the fact that the user might find the use of LBM pleasant or easy to use, or even useful or locating products and services.

From H19-H20 the fact that the user can locate easily the products/services is correlated to the fact that LBM is pleasant to use or that the businesses can collect much information regarding the users. On H21 the belief that pleasant is to find fast information for products/services through LBM is correlated to the belief that service providers can collect much information for the user of LBM.

One limitation of the current research is that it focuses on specific factors of TAM theory without expanding in additional that exist in other researches. The statistical analysis provides with indicatives of potential correlation and needs to be further examined with S.E.M., to check values such as coefficient and P value.

CONCLUSIONS

Adding the location dimension is beneficial in terms of view, feelings and needs of users for a particular physical location, as well as the ability to arrive at the right time and location with relevant content, to engage and interact to share their experiences, which is the essence of advertising. As expected, marketers are seeking new technologies to reach customers more effectively and gain competitive advantage over market competitors (Pick 2012).

In terms of technology, demand will increase for internal LBS. Many startups are working in this field, combining wireless geo-magnetic sensors and beacons to complement GPS. The use and application of LBS will create a better environment that will be enhanced by Artificial Intelligence (Poulovassilis 2013). Motor vehicles that have been improved with LBS will make a major progress in transport. Augmented reality is a field where the real and the virtual world combine to offer a wide range of applications. The operation of these applications will largely depend on location data (Beeck and Toporowski 2017).

In the future, internal and external LBS can also be integrated, which will facilitate seamless M2M (machine-to-machine) communication. One application would be to communicate the car's LBS with the home heating device and turn it on 10 minutes before someone arrives home. Emergency, rescue and disaster management will use LBS in the near future (Sarwat et al. 2018).

The growing popularity of cloud-based analytics is one of the forthcoming market-winning trends. Large data analytics enrich knowledge of consumer market patterns so that retailers can increase their sales volume and improve customer search experiences. Location-as-a-Service companies, use large data analytics to deliver cloud-based and mobile LBS web services that can integrate real-time location information as well as data analytics. For brands, it is not just about knowing where a customer is, but also where their attention is, and this is made possible by technology.

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Literature Review of Location Based Services

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Abstract

Location Based Services (LBS) utilize sensors from smart devices and provide accurate positioning estimation for end-users on indoor and outdoor environments. With Internet of Things(IoT) getting higher recognition amongst regular users a variety of daily tasks is getting depended on the efficiency of service providers and enablers in order to be executed successfully. With a market that is growing and demands better indoor and outdoor solutions for real time positioning estimation, enterprises are competing each other on technological research and development of new products and services. The Scopus of this research is to identify potential gaps on the field of LBS for both academic and business sector. For this reason, we made a systematic research of the last 20 years of publications by using relevant keywords on digital scientific libraries. We identified lack of scientific publications on the Business and Management field where we further isolated researches with Business and Managerial interest. We highlight specific Grounded Theories that have not been fully exploited, on the field of LBS, since only a few researches exist that examine the adoption and success of LBS. Future researches have the opportunity to exploit our gathered sample of researches and extend the presented research models in order to provide the Academic and Business community with new knowledge.

KEYWORDS

Location Based Services, Location Based Mobile Applications, Literature Review.

INTRODUCTION

LBS have been a subject of research for many years. The constant evolution of technology regarding smart mobile devices has brought new opportunities not only for research but also for commercial purposes. Geolocation when it comes to outdoor usage seems to be fulfilled in terms of research activity. On the other hand, Indoor Positioning Systems (IPS) are rising since the advent of new technologies such as Beacons on the early 2015 and seems that there is a huge gap concerning the adoption of such technologies and how they have been exploited by the research community for exporting useful information regarding User Behavior (Fellner, Huang, and Gartner 2017).

LITERATURE REVIEW

There are numerous researches that are utilizing smart devices for the shake of technological advancements, others for the creation of a new innovative service that can revolutionize the customer experience and enhance VR experiences (Foth et al. 2009). The minority are literature review papers that are determining the studies that have the highest impact and separate the categorization and the field of each one in order to be further utilized in future work (Kárník and Streit 2016).

The field of LBS lack of researches that focus simultaneously on both the technology stream and the research stream based on stable frameworks and theories (Khruahong et al. 2018). As a result, this field opens significant opportunities for researchers that want to explore Behavior of end users in addition to an innovative solution to approximation location problems such as IPS (Wu, Kao, and Yang 2012).

Also, the managerial implications of the current research in LBS seems to be left behind comparing to other relevant disciplines such as information systems-oriented researches (Rinaldi 2009). There seems to be another gap on the management perspectives and consequences of the Location Based User Generated data that can unlock new insights on the managerial enchantments that can be utilized for research purposes (Tiru et al. 2010) (Azlan et al. 2017).

It seems that location-based services are highly connected with mobile phones that can offer mobility while using these services (Curran and Hubrich 2009). Moreover, the content created by these applications are highly correlated by the usage of the typical users (Gummerus and Pihlström 2011).

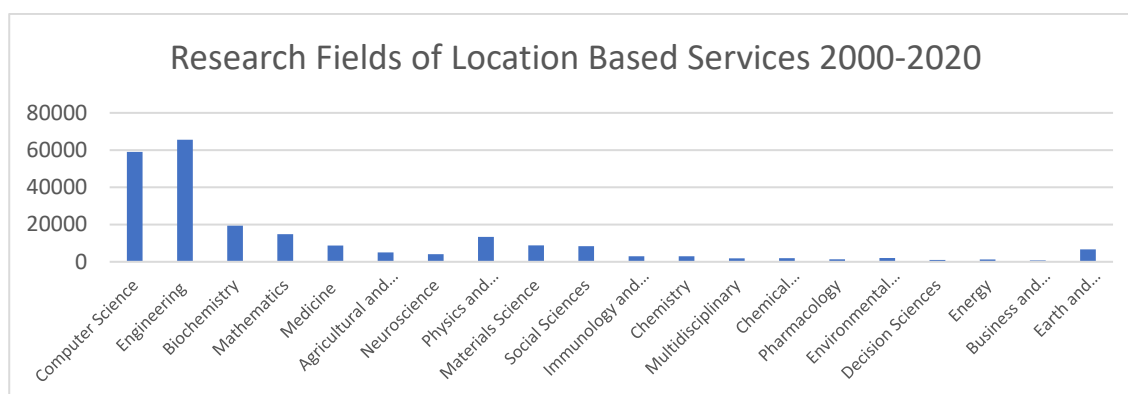
Specific researchers have identified the fact that geospatial information is driven by behavioral characteristics since motivation is a major fact for every single transportation (Girardin et al. 2008; Espeter and Raubal 2009; May, Bayer, and Ross 2007). Others have classified the transportation methods-means into different classifiers in order to better understand how geotagging is performed by end users through social media (Tamas and Toth 2018). It seems that different means of transportation lead to different transit behavior such as more waiting times or different time of walking times. Another interesting behavior that is unveiled is the fact that the geotagging performed in social media is not always valid since many people make check in after their activity is over (Rybarczyk et al. 2018). Indoor location technologies applied inside libraries can better explain behavioral characteristics that are relevant to book content and the provided services on specific areas of every library (Von Stülpnagel and Schmid 2019). Classification of books is made easier and faster, as is the control of the availability and the demand for thematic units and specific text content. Researchers can identify the days and hours that libraries are facing their higher demand and optimize their offering services for better results (Liu and Hsu 2018). The impact of Location Analytics into Business intelligence has been confirmed by the fact that more than 60% of the big data on the internet has geo-reference component. Hence Location Analytics is a new area that was merged by Business Intelligence (Rybarczyk et al. 2018). The combination of Geolocation Analytics with Location Intelligence has brought the advent of Intelligence analytics. Location analytics can enhance the user experience by verifying the optimal site for the nearest restaurant or ATM, or the number of locations that a market can support, and the business effect that the competition sales potential has (Chen, Chiang, and Storey 2012). Behavioral characteristics and applications have raised high interest regarding the analysis of user intentions while using IPS and how they can interact with a smartphone application (Huang et al. 2018). Although people usually are not easily familiarized with new user interfaces, they seem to outperform tasks when they are asked to through an indoor Location-Based service (May, Bayer, and Ross 2007). Also by giving them tasks they had a better user experience for events such as a visit to a museum and the like (Chianese, Piccialli, and Valente 2015).

METHODOLOGY

We have utilized a variety of academic libraries that helped us in order to cover the majority of the significant publications of the last 20 years for the purpose of this research. The libraries that were utilized for this purpose were Emerald, ScienceDirect, Scopus, Wiley InterScience. Furthermore, the classification of the publication according to the different fields is executed with filters that can be applied on the online site of the prementioned libraries (Schlichter and Kraemmergaard 2010). Moreover, we have used specific keywords in order to isolate specific implemented technologies such as “Location Based Services”, “Location Based Mobile Applications”. While applying the keywords on the other Services we specifically used the keywords GNSS receivers, Ultra-Wideband, Wi-Fi Positioning System, Visual Light Communicator since with the acronyms we were losing a large number of publications (Webster 2002). On this first stage we have applied a minor filter in order to separate the publications that are included only on Scientific Papers and Journals which are easier to access than others such as Book Chapters and “under review” Papers or Articles. The first phase contains 222603 selected papers that were isolated by applying the prementioned keywords, contain the 20 years of research on LBS.

The following figure presents indicatives regarding the research on LBS has been implemented the last 20 years. It is also insightful by providing the departments where research has put the most and the least effort in terms of quantity of publications.

Figure 1. Research Fields of LBS 2000-2020



Engineering and Computer Science have the highest point of interest as a Discipline on the field of LBS due to the high value of input that have through the years on LBS (Torteeka and Chundi 2014). Engineering seems to be the highest applicable field regarding LBS since it is the fundamental process when it comes to new innovative products on every single industry. The way that is implemented can affect the accuracy of LBS (Al Qathrady and Helmy 2017). From the way that a product is designed and the location that a technology is implemented, has a tremendous effect on the accuracy of the implemented method and the final results that will be delivered (Claus and Martin 2004). On the other hand, Computer Science is having the most targeted field regarding publication researches when it comes to publications (Yang et al. 2015).

Following this path, we isolated the field of Business and Management for two main reasons. It is nearest to our expertise, and it has the minority of all the LBS publications which potentially brings more academic opportunities for research gaps and publications. By examining those researches, we have reached to a point where we could identify 2 kind of researches. The first one was the exploratory type of researches were different technologies were implemented and tested in order to provide LBS environment with improvement to indoor and outdoor location. The second type of researches were based on specific Grounded theories that were relevant to the success aspects of LBS and the paragons of adoption for end-users and businesses with relevant managerial and business aspects. In order to identify research gaps, we carefully studied these publications in order to find the Grounded-research theories that were utilized for their research. From this process we isolated 11 researches that utilize the aspect of Location into their Services and Examine this unit of analysis under specific Grounded Theories.

Table 1. LBS Researches with Grounded Theories

No	Researches	Year	Theoretical Model
1	A Study on User Behavior Analysis of Integrate Beacon Technology into Library Information Services	2018	TAM
2	Determinants of behavioral intention to use the Personalized Location-based Mobile Tourism Application: An empirical study by integrating TAM with ISSM	2019	TAM
3	The Impact of Location-Based Service Factors on Usage Intentions for Technology Acceptance: The Moderating Effect of Innovativeness	2018	TAM
4	Understanding Motivations and Acceptance of Location-Based Services	2016	TAM
5	What promotes smartphone-based mobile commerce? Mobile-specific and self-service characteristics	2017	TAM
6	Acceptance of Smartphone-Based Mobile Shopping: Mobile Benefits, Customer Characteristics, Perceived Risks, and the Impact of Application Context	2017	UTAUT
7	Usage factors of location-based social applications: the case of Foursquare	2018	TAM/UTAUT
8	User acceptance of location-tracking technologies in health research: Implications for study design and data quality	2018	UTAUT
9	Success factors in developing iHeart as a patient-centric healthcare system: A multi-group analysis	2018	Delone & McLean / TAM
10	The role of personalization on continuance intention in food service mobile apps: A privacy calculus perspective	2018	TAM/Privacy Calculus Model
11	What Influences Travelers' Adoption of a Location-based Social Media Service for Their Travel Planning?	2013	UTAUT
12	User acceptance of location-based social networking services: An extended perspective of perceived value.	2013	TAM

We can see that the majority of the theories involved are TAM and UTAUT with the exception of 2 studies that utilize Delone and McLean model and Privacy Calculus Model. 6 utilize the TAM model 3 the UTAUT and 3 are use multipurpose Models which are totally TAM, UTAUT, Delone and McLean, Privacy Calculus Model. Moreover, they are the researches that try to extend the already existing models and create more broad perspectives of research on the field of LBS.

Another interesting fact is that the majority of the studies are from 2017 with the exception of one that is from 2013 and utilizes UTAUT on the Tourism industry.

CONCLUSIONS

In the last 20 years seems to exist relatively few researches published to scientific conferences and journals worldwide regarding user adoption as TAM and UTAUT examine, which leaves potentially great room to grow on this field. From the current research we identify a potential big gap regarding LBS and the exploitation of research models. Potentially this could explain the reason why these Services have not been adopted by Businesses and end-users among many other reasons such as the privacy and the legal pitfalls which are not a subject of study in the current research. With many studies proving that LBS can be a part of Businesses Digital Transformation we expect that more studies can exploit the research gap and provide with additional knowledge Business and academic sector. A future work for the current research could be a synthesis of a research model that is based on TAM/UTAUT and provide an extension with concepts that have not been studied yet in combination with other already studied. This potential future work can provide with correlations and knowledge that LBS sector might need to move on and be further established in the near future for both academics and businesses.

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Session 11: Business Analytics & Big Data

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Strategic Value of Big Data and Business Analytics

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Abstract

The proposed paper firstly provides a literature review to highlight the theoretical and practical contribution of the strategic value of big data (BD) for businesses and to define the individual concepts characterizing this area. The methodology followed for the literature review is that of Webster and Watson (2002) which has been applied to a variety of Information Systems. Based on the above, a theoretical framework of strategic value of BD for businesses is formed.

KEYWORDS

BD strategy, business analytics, strategic value, analytics capabilities, BD strategy process, literature review.

INTRODUCTION

The vast increase of data from different sources and in various forms has raised researchers' interest in BD. Practitioners share knowledge, improve decision-making (DM) and support strategic planning through data analysis techniques. Numerous studies focus on the success of BD analytics techniques and relevant resources but little research is on their strategic contribution. BD is characterized by 4V's. In recent years, researchers have added value from data as a fifth. The success of BD projects and analytics techniques requires not only the right infrastructure, analysts, knowledge and tools for BD, but also turning them into strategic value (Kitchens et al. 2018; Grover et al. 2018). The purpose of this paper is to form a framework of BD strategic value, incorporating its' fundamental concepts as analyzed in the literature. In the next pages, subsection 2.1 provides information about the review methodology, 2.2 includes the review results, in 2.3 the basic concepts, their components and alternative views are described, based on the review findings. In section 3 the proposed BD strategic value framework is presented. Finally, brief conclusions of the paper are quoted.

LITERATURE REVIEW

Review methodology

A literature review is important in order to highlight the theoretical and practical contribution of BD strategic value for businesses and to define the individual concepts characterizing this area. The methodology followed for the literature review implementation is that of Webster and Watson (2002) which has been applied to a variety of Information Systems' research (e.g., Kamariotou and Kitsios 2016; Kamariotou and Kitsios 2017; Kamariotou and Kitsios 2018; Kamariotou et al 2018; Kamariotou and Kitsios 2019a; Kamariotou and Kitsios 2019c; Kitsios and Kamariotou 2019a; Kitsios and Kamariotou 2019c; Kitsios and Kamariotou 2019d). As a primary stage, seemed appropriate to search previous literature reviews in the field of the strategic value of BD and business analytics, in order to study keywords, search platforms, scientific fields and search areas used before. A search of the literature reviews revealed 14 papers. Exploring these reviews helped determine the keywords for our research as follows: BD, strategy, strategic value, business analytics, data mining. Databases selected in our search are Scopus, Science Direct and Web of science. Filters selected are publishing date after 2010, English language, document type Article, Conference Paper or book chapters, source type Journals or Proceedings and the fields of Computers, Business, Management, Decision Sciences, and Economics.

Search Results

A total of 1002 results were obtained from the 3 databases. 773 of them were rejected by title, as only 229 were considered to have a strategic or business approach and not purely technical scope. The above results were then limited

to 130 based on their summary. Adding some new papers using the backward and forward search and removing duplicates and papers with not full text available, ended up to 74 final papers.

Figure1 Selected papers per year

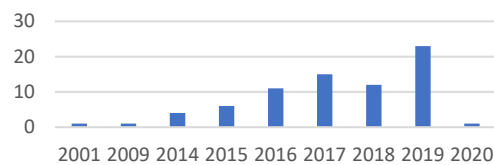


Figure 1 illustrates selected papers per year. For 2020 papers selected are limited to the 1st quarter. Also, before 2014 the “big data” term is not present in the results. So, judging by 2014 – 2019 period, the published papers increase rapidly, following the “big data” idea raised interest. Specifically, yearly rate in our selected papers is 95%, while the rate of all publishing scientists worldwide is approximately 4-5% per year.

Analysis of concepts

There are some basic concepts that constitute the current literature under the BD strategic value objective. In the next section, these basic concepts, their components and alternative views are described, based on the review findings. In the next paragraphs the paper’s most relevant findings are presented categorized under the basic concepts of BD strategic value.

BD sources: New data streams of the last two decades practically gave birth to the term and phenomenon of BD. It is widely accepted that BD sources are characterized by the 3 Vs. Volume refers to the increasing amount of data sources, velocity to the increasing pace at which these streams generate data and variety to diverse types of data sources. According to Constantiou and Kallinikos (2015), strategic management theories underline the need for several sources of information necessary to strategy making but they don’t focus on the processes used for these sources of information, their combination and interpretation in order to become relevant to strategic pursuits. Grover et al. (2018) indicate that integrating diverse sources of data to create a platform for analytics, in an environment characterized by four Vs is not easy. According to Müller and Jensen (2017)’s research, companies use both structured and unstructured data from internal as well as external sources. Internal data include financial, sales, CRM, ERP, and usage statistics data as well as mails and use cases. External data include social media, industry reports, public databases GIS and EDI data.

BD investment projects: Implementing BD and transforming its processes, tools, people or even strategy is a critical decision. Several factors may influence this decision, including expected benefits and downsides from implementation, cost, requirements, etc. Kitsios and Kamariotou (2019) argue IT investment is a crucial issue and influences alignment between business strategy and organizational performance. Bhimani (2015) indicate that firms accelerating investments into digital capabilities to enable DM open up whole new orders of data volume, specificity and form. Grover et al. (2018)’s framework embraces the idea that increasing BDA infrastructure investments in the quality and quantity of data and data management assets, analytics portfolio, and analytical skills will enhance BDA capabilities. Woerner and Wixom (2015) think digital transformation results to the development of business ecosystems that offer more choice, information and value to consumer. Depth of knowledge of the consumers becomes an investment key dimension for company strategy. Grover et al. (2018) state that leveraging BD to achieve strategic business value requires significant investment in data infrastructure, analytic technologies, skilled analysts and strategic positioning. Ylijoki and Porras (2019) created a model to explain how BD investments are transformed into improved economic performance and why such investments sometimes fail. Their concept is that firms first make investments to create BD assets and then transform assets into impacts with the appropriate BD capabilities. Côte-Real et al. (2017) suggest BDA can be a strategic investment to enhance organizational agility supported by BDA. Sheng et al. (2017) support that top management teams should make strategic adjustment within organizations through investments in IT innovation and data analytics skills development.

BD performance: Grover et al. (2018) recognize the following BD performance impacts: Profitability, Return on assets, Equity price, Symbolic value, Fraud detection and Market forecasting. Ylijoki and Porras (2019) created a holistic model, using data, information, knowledge and wisdom, explaining how BD investments translate into firm performance. They argue BD impacts need to be linked to actual performance metrics which connects the firm to its industry, ecosystem, competitors and customers. Raguseo (2018) recognize 4 different kinds of BD benefits by companies: transactional, strategic, transformational and informational.

BDA capabilities: Akter et al. (2016) consider BD analytics capability (BDAC) as the competence to provide insights using data management infrastructure. Their model, identifies 3 types of BD analytics capabilities: BDA management capability (planning, investment, coordination and control), BDA technology capability (connectivity, compatibility and modularity) and BDA talent capability (BDA technology management knowledge, BDA technical knowledge, BDA

business knowledge and BDA relational knowledge). Olszak and Zurada (2019) consider ICT infrastructure as “fragile” capability in business value terms, concluding that firms derive their value mainly from intangible capabilities. Their research results highlighted the need for constant learning in analysis and interpretation, employees with analytical skills and creativity and management using BD in DM. Grover et al. (2018) consider BDA capabilities as the ability to integrate, disseminate, explore and analyze BD. They propose for further research database integration, data dissemination, data volume handling, data variety handling, external data integration, data analysis designing and data outputs interpretation. They noted the “learning by doing” cycles as important for strengthening BDA capabilities. Ylijoki and Porras (2019) suggest that BD initiatives require new organizational and managerial capabilities to drive the transformation toward data-driven business. They discrete technical (hardware, algorithms) and human (analytics, innovation, information management, data culture) capabilities. Wang et al. (2018) identify unstructured data analytical capability, decision support capability, predictive capability, and traceability.

BD strategy: Akter et al. (2016) think aligning BD analytics capability and business strategy depends on visionary leadership that helps synchronize capability and functional objectives. Bertei et al. (2015) propose a framework focuses on how the identification, evaluation and selection of BD sources impact on strategic DM process. Bhimani (2015) believes firms using BD based DM are likely to experience faster growth from effective strategic action. Moreover, he points out that BD analyses from existing customers can provide information enabling barriers to challenger’s entry. Mazzei and Noble (2017) present a framework that identifies BD as a key component of innovative and disruptive strategies used to diversify and break down barriers of traditional industries. On the same side, Constantiou and Kallinikos (2015) suggest that updatability of BD and reduced time span of data can challenge the structured information, lasting value and long-term objectives of traditional strategy. They expect a profound change in strategic management models that focused on managerial cognition and overemphasized the role of executive managers in interpreting and using environmental information for making strategic choices. They analyze the shift in business strategy context with the new BD ecosystem on its basic elements: from homogeneous structured information to unstructured, or semi-structured, from purposeful and theory-driven to Agnostic, Haphazard, from deductive and top-Down to Inductive and Bottom-Up, from long-term to short-term and from forecasting to nowcasting. On the other hand, Woerner and Wixom (2015) think that BD is not an impediment to strategy, instead it offers rich, exciting opportunities to leverage and extend a company’s business strategy toolbox. Olszak and Zurada (2019) research results indicate strategic significance from BD processing in establishing customers and suppliers contacts, faster learning customer market trends, reducing risk of investing in new products and services, and more efficient supply chain management. Raguseo (2018) recognizes as strategic benefits of BD: better products and services ability, ability to align IT and business strategy and ability of quick response to changes in the business environment.

BD value creation: Woerner and Wixom (2015) think increased digital transformation results in the development of ecosystems, coordinated networks, devices, and consumers that create value. Olszak and Zurada (2019) formed a BD driven value creation framework with: dynamic capabilities, integrated process of BD resource exploration and exploitation, and identification of business value creation based. Grover et al. (2018) note that successful BDA yields strategic value in functional form (market share, financial performance) and symbolic form (brand image, environmental pressure). They propose BD value creation with 6 linkage mechanisms between BDA capabilities and value targets and identify 4 targets of BDA value creation. Ylijoki and Porras (2019) present a process-theory model of BD value creation. They recognize the main areas BD can add value: a. speed, quality, real-time and automation in DM, b. operational efficiency, c. product innovations and d. business model innovations. Côte-Real et al. (2017) suggest BDA can provide value at a.knowledge b.dynamic capability c.business process and d. competitive performance. Müller and Jensen (2017) show elements of BD real value creation i.e. data, enterprise, leader, target, technology and analysts. Sheng et al. (2017) show that value created through BD does not arise from data or technology alone, but firms need to formulate and implement a data-driven strategy. By leveraging BD into management mechanism, additional values can be discovered, created and realized in business development. Kitchens et al. (2018) found out that the ability to measure value of each data channel is important. Wang et al. (2018) mapped the benefits by BD analytics in terms of IT infrastructure, operational, organizational, managerial and strategic areas. Wamba et al. (2015) think firms need to leverage the information eco-system arising from the BD adoption to share real time information, understand customers, optimize supply chain and human resources, improve financial metrics and develop critical insights for DM.

PROPOSED FRAMEWORK

Having reviewed the theoretical and empirical concepts, requirements and implications of BD, especially under their strategic and added value view, we are able to draw the basic elements and relations of a BD strategic value framework for SMEs. We reform the methodology of Kitsios and Kamariotou (2019) who used Strategic Information Systems Planning (SISP) to represent the components of the strategic planning process. We also use the strategy process description by Chaffey (2009). In our case we use an integrated process containing specific 4 phases, to represent the components of the BD strategic planning process. These phases are: a. the BD strategy analysis b. the definition of BD implementation objectives c. the strategic implementation of BD and e. the BD value assessing.

Phase 1. BD strategy analysis: The initial phase for strategic BD transformation in a firm is analysis of: a. Internal resources, i.e. assets of the company and their transformation to BD capabilities. Training for analytical HR, management innovative culture, BD infrastructure and knowledge management should be evaluated either as a strength or a weakness in the DB value chain. b. External micro-environment, including BD demand forecasting, competitors BD activity, marketplace IT structure, data sharing with customers, suppliers and partners. c. External macro-environment, including IT and technology development, private data regulation, social data sharing trends, ethical constraints and economic factors. The above external environment elements should be evaluated either as a threat or an opportunity in the BD value network.

Phase 2. Definition of BD objectives: Phase 2 is about defining the firms' BD vision and translating it to specific objectives. This phase should include: a. formation and selection of alternative BD strategies with regard to range, type, expectations, b. strategic targets and goals setting, e.g. market development, product development, segmentation, differentiation, market penetration, c. creation of strategic performance metrics.

Phase 3. Strategic implementation of BD: Strategic implementation of BD should be considered both as an investment project and an ongoing process. Implementation requires all the following decisions: a. budgeting investment for ICT infrastructure, BDA applications, database infrastructure, b. BD resource distribution between IT, HR, marketing, production and SCM, c. BD resource planning, programming, d. Business structure transformation for enhanced organizational agility, innovation and ecosystem culture, e. Business processes transformation for connectivity, compatibility and modularity, f. HR upscaling for analytical skills, data culture and information management.

Phase 4. BD value assessing: This phase is about monitoring, evaluation and report of BD implementation results in terms of value creation. Value assessing phase is critical for the whole framework process. This phase should include the following: a. assessing real value gained after BD implementation at each data channel, b. providing continues feedback to Phase 1 for reevaluation of the BD strategy, c. monitoring BD assets transformation to BD capabilities, d. accounting BD implementation impacts for the targets, goals and performance metrics set at Phase 2.

CONCLUSIONS

In this paper we reviewed the literature to highlight contributions of the strategic value of BD and to define the basic concepts under the BD strategic value objective. We draw the basic elements and relations of a BD strategic value framework for firms. Specifically, we used an integrated process containing specific four phases, to represent the components of the BD strategic planning process. Our literature review findings highlight limitations in determining and assessing strategic value in real business cases. Future research should aim for empirical research under specific metrics for BD strategic value.

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The Impact of Artificial Intelligence and Operational Research Cooperation on the Finance and Business: A Literature Review

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Abstract

Nowadays, due to the globalization of entrepreneurship and the rapid improvements in the information and communications technology, businesses need to use the right tools and procedures to be competitive. Artificial intelligence can play a key role in this. During the last decades, artificial intelligence and especially machine learning are becoming more and more established in the field of academic research and commercial utilization. According to recent studies the global GDP may increase by up to 14% by 2030 as a result of the development and adoption of artificial intelligence technology. However, enterprises have to reinvent their business model in order to integrate artificial intelligence technology into their daily procedures and implement an artificial intelligence strategy. Furthermore, there is a growing research in the interaction of machine learning and operational research. The main purpose of this paper is to highlight and analyze the impact of artificial intelligence in business and finance and its added value to operational research. For this reason, we provide a review of the current scientific research regarding the applications of artificial intelligence and especial machine learning in the fields of business and finance from an operational research point of view.

KEYWORDS

artificial intelligence, machine learning, operational research, finance, business

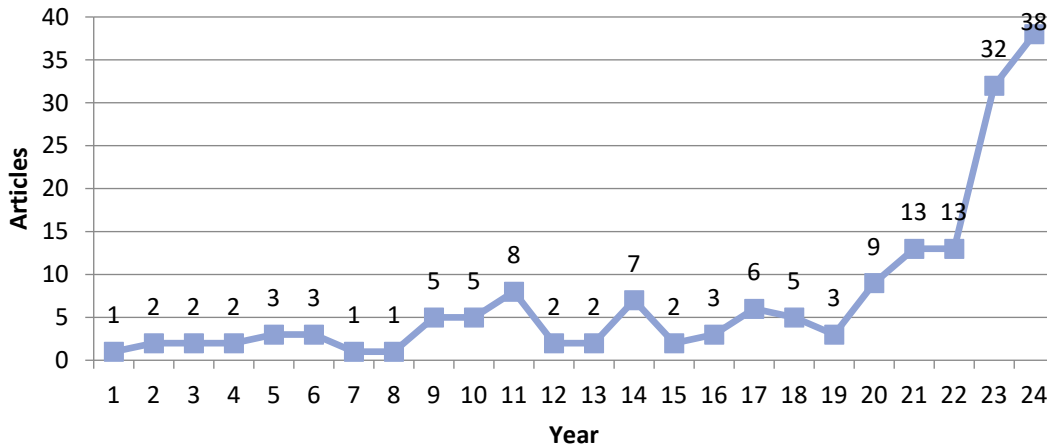
INTRODUCTION

During the last years there is a growing interest on how artificial intelligence techniques and especial machine learning can cooperate with operations research both in methodological research and real word applications. Moreover, many scientific papers present the promising predictive capabilities of machine learning techniques. Optimization is essential for machine learning (Bennett and Parrado-Hernandez;2006). On the other hand, operations research provides the tools that can improve decision making using the right optimization models. How can these two scientific fields cooperate effectively? The hybridization of machine learning and operations research by developing new algorithms could be a solution. In this paper we try to answer the following questions: How many papers are published in operational research journals each year during the period 1980 - 2020? Which operational research journals have published the highest number of publications? Finally, we review the papers that combine machine learning and operation research in business and finance applications. In most of them, machine learning methods are used to make predictions and then operations research methods are used to optimize those predictions.

MACHINE LEARNING AMONG OPERATIONAL RESEARCH SOCIETY

In order to investigate the synergy of artificial intelligence and in particular machine learning with operational research, we started the literature review focusing initially on internationally recognized journals dealing with operational research. Kraus *et al* (2020) after review all papers published in top journals of operation research society by October 2018 found only three papers applying deep learning methods. They extend their work using real data of operation research problems and conclude that deep neural networks can increase operational performance. Also, Ormerod (2020) searching in google scholars papers published in Journal of the Operational Research Society during the last fifty years and found 66 mentions the term Artificial Intelligence. In this paper, we conducted research in SCOPUS database for the period 1980 – 2020. The search was performed using the keyword “machine learning” and limit it to sources titles that contained the keywords “operational research” or “operation research”. The search results numbered 168 articles. As we can see in Figure 1 during the last two years the number of articles dealing with machine learning in the context of operational research has increased significantly compared to previous years.

Figure 1. Number of articles per year in the initial search



Related papers have been published in 18 scientific journals. The following 5 journals published 10 or more articles. European Journal Of Operational Research collects the most articles (37.5% of total articles), followed by Annals Of Operations Research (19%), Computers And Operations Research (11.9%), Journal Of The Operational Research Society (8.3%) and Operations Research (6%). The other journals in the operations research domain published less than 10 articles.

Table 1. Articles per Journal

Title of Journal	Number of Articles
European Journal Of Operational Research	63
Annals Of Operations Research	32
Computers And Operations Research	20
Journal Of The Operational Research Society	14
Operations Research	10
Journal Of The Operations Research Society Of China	7
Asia Pacific Journal Of Operational Research	3
Mathematical Methods Of Operations Research	3
Mathematics Of Operations Research	3
Operations Research Computer Science Interfaces Series	3
Croatian Operational Research Review	2
International Transactions In Operational Research	2
Central European Journal Of Operations Research	1
Military Operations Research	1
Operations Research For Health Care	1
Operations Research Letters	1
Operations Research Perspectives	1
Yugoslav Journal Of Operations Research	1

THE COOPERATION OF ML AND OR IN BUSINESS AND FINANCE

In the next step of our research we limit the above number of articles only to those who focus on machine learning and operation research methods for business and finance applications. According to this criterion the remaining articles are 71. The most of them deals with financial risk management and analysis. Kim *et al* (2020) use deep learning networks for hedging decisions in the spread-trading market. Their proposed DNN model outperforms traditional rule based and machine learning methods. Chen *et al* (2020), modify Markowitz portfolio model by using machine learning approaches with sparse-group lasso regularization increasing its performance compared to minimum-variance portfolio. The

beneficial use of machine learning approaches for stock return predictions and portfolio management is also presented by Kyriakou *et al* (2019), Huck (2019) and Avdoulas *et al* (2018). Akyildirim *et al* (2020), applied machine learning techniques in cryptocurrency market with promising results. On the other hand, Doumpos *et al* (2020) compared linear regression models with machine learning methods for real estate valuation using data from Greece. They argued that locally weighted linear models can give better results than random forests and Gaussian process regression approaches. Furthermore, there is also collaboration of machine learning and operational research methods in the field of sales forecasting, credit risk assessment and management. Zhou *et al* (2020) use clustering method, multiplicative regression and genetic algorithm in order to improve the forecasting accuracy using sales data from an online store. The development of a demand prediction model incorporating data mining and machine learning techniques is proposed by Van Nguyen *et al* (2020) using real data from www.amazon.com. Martinez *et al* (2020) using data from a B2B unit, found that gradient tree boosting method performs very well for sales forecast. Kharfan *et al* (2020) applied regression trees, k-NN, linear regression, random forests and neural networks for optimization demand forecasting of products without historical data. For more effective forecasting, they emphasized the use of data preprocessing. However, Carbonneau *et al* (2008) did not find statistically significant superiority of the examined machine learning methods over more traditional demand forecasting methodologies. Other examples of using machine learning techniques for demand forecasting are presented by Van Belle *et al* (2020) and Huber *et al* (2019).

Luo *et al* (2020) propose an unsupervised kernel-free quadratic surface support vector machine model. Using data from a credit risk assessment application they found that their proposed model has high classification accuracy. The efficiency of various classification methods for credit risk assessment applications was also tested by Sariannidis *et al* (2019). They found high accuracy rates for all tested machine learning approaches and also presented the major variables of debtors' default according to these models. Liang *et al* (2016) compare some of the most known machine learning techniques for bankruptcy prediction. They argued that stepwise discriminant analysis with support vector machine have the best performance. Kim and Ahn (2012) applied a novel multi-class support vector machines approach using credit rating data. According to the experimental results, their proposed algorithm outperforms other statistical and machine learning techniques. Combination of statistical and machine learning methods for credit risk assessment can also be found in the work of Florez-Lopez (2007), Liu and Schumann (2005) and Piramuthu (2004).

The contribution of machine learning in supply chain management especially at the agricultural sector is presented by Sharma *et al* (2020). They review 93 papers and proposed a framework in order to improve decision making in agricultural supply chain. Liu *et al* (2020) applied machine learning methods for the analysis of competition in automotive market. Gartner and Padman (2020) used machine learning algorithms with discrete-event simulation models for healthcare management applications while Galli *et al* (2020) argued that random forest and XGBoost-based models can improve inventory management also in the healthcare sector. Baechle *et al* (2020) developed a natural language approach for patient readmission prediction that can be effective for the cost optimization. Finally, Smirnov and Huchzermeier (2020) proposed a combination of an ARIMA model with gradient-boosting for labor planning.

CONCLUSIONS

In recent years more and more papers are published across the premier journals in the field of Operational Research. Some of them concern the development of hybrid systems of machine learning and operational research and their application, among others, in business and financial applications, others attempt to compare the results of the two cognitive areas while others attempt to investigate the relationship between them. The literature review shows that the synergy of machine learning techniques with operational research tools can contribute to more effective decision making. Future research could include a more detailed bibliographic review of the interplay among machine learning and operation research in a wider range of peer-reviewed journals. In addition, a survey could be made of all the new algorithms that have emerged from the cooperation between these two scientific areas.

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Augmented Analytics: A new era for Human Resource Management

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Abstract

In recent years, Human Resources (HR) departments have overstepped their usual role and evolved into a department with strategic significance. This transition emerged mainly through the adoption of technological advanced tools which offered to HR people new intelligence. For example, People analytics (PA) has transformed the way the HR department works, while companies more than ever need data-driven decisions. By applying statistics and machine learning techniques, PA provides insights that allow them to make better and strategic business decisions, improve employee training, reduce employee turnover, and make acquiring talent more effective. Further, Augmented analytics (AA) brings automation to the HR departments' operations, improves analytics cycle, changes the business intelligence, and supports automated data-driven decisions. As the volume of data increases and became big data, augmented analytics becomes valuable by involving artificial intelligence (AI), machine learning (ML), and natural language processing (NLP) methods to provide managers with a more user-friendly approach to analyze HR related data. Thus, AA is capable of supporting various processes and HR decisions and increase hiring efficiency, control voluntary attrition, and improve employee engagement. This paper examines the steps of a proposed AA framework that can be applied in HR. Firstly, we discuss the existing literature in AA and review the analytics cycle of applications in HR. Secondly, we suggest a theoretical framework for examining different scenarios and displaying the advantages and disadvantages of AA applications throughout the analytics cycle. The use of the proposed framework produces several implications and suggestions for further research, since it becomes obvious that AA is increasingly becoming a vital factor positively affecting business growth, thus evolving into a Decision Intelligence approach.

KEYWORDS

Human Resources Management, Augmented Analytics, HR Analytics, Decision Intelligence, People Analytics, Business intelligence.

INTRODUCTION

The multi-faceted business environment and globalization create business opportunities and challenges. Since the middle of the last century, the Fourth Industrial Revolution is building the business digital revolution (Xu et al., 2018). Today the Industrial Revolution is changing business models with some which are based on digitization and data. Features of the Fourth Industrial Revolution are Artificial Intelligence (AI) & Machine Learning (ML), The Internet of Things (IoT), Big Data, Blockchains, Edge Computing, Robots, Autonomous Vehicles, 5G Network, Quantum Computing (Marr, 2020).

Within the last ten years, the rapid growth of digitized data has brought research opportunities for Big Data Analytics and Business Intelligence in management, Social science, and humanity (Liang & Liu, 2018). To gain advantages, companies have always sought to extract intelligence from data. Business Intelligence (BI) is defined by Kimble & Milolidakis (2015) as the ability of a company to make meaningful use of data it collects in its day-to-day business operations, thus supporting decision-making in every area of the company.

The term Big Data refers to large, growing data sets that include structured, unstructured, and semi-structured data. Those require potent technologies and advanced algorithms to process (Oussous et al., 2018). Consequently, Data Analysis and Big Data Analytics (BDA) are necessary tools for the companies which are aware that data analysis is becoming a critical factor in discovering insight (Hamilton & Sodeman, 2019). BDA provides methods and tools for gathering, processing, and analyzing large amounts of data (Zhang et al., 2011).

Although these tools have been applied for many years in every department of a company, it is only recently that HR Department started giving to them the attention they deserve. In this paper, we focus on the relationship between these tools and the Human Resources Department to assist in decision making. Human Resource Intelligence (HRI) consists of methods for making facts-based human resource decisions in an enriched environment of BI (Kapoor & Sherif, 2012). The functions of Human Resources in the current fourth industrial revolution have been expanded to a

new direction, called People Analytics. People Analytics (PA) is defined as the combination of different internal and external data sources of the company that is required to respond and act upon forward-looking business questions associated with the human capital assets of an organization (You et al., 2016).

Therefore, People Analytics and, generally, the ability of a firm to use predictive analytics when dealing with HR related issues has become a mainstream, while optimizing the data analysis using all available technologies, such as those that contained in Augmented Analytics, is now a principal aim for highly competitive companies. So BI combines Data Science, Augmented Analytics and decision making to evolve into Decision Intelligence. It is obvious from the foregoing arguments that those methods bridge the gap between technology and the natural way managers used to take decisions until now.

The rest of this paper is organized as follows. A short literature review concerning Analytics and Human Resource Management is presented in Section 2, while a life cycle of Augmented Analytics and how it can be used in HR is discussed in Section 3 and, finally, some general conclusions are briefly given in Section 4.

LITERATURE REVIEW

Traditionally, HR department's functions and primary responsibilities mainly included keeping personnel records, determining wages and other benefits. Nowadays, however, it is also in charge of attracting talents (talent management), predicting and preventing turnover and predicting hire success. For example, HR Analytics is an HRM application that is designed to provide managers with information that connects HRM processes to employee attitudes and behaviors and, finally, to organizational outcomes (Marler & Boudreau, 2017). Further, Data Science, the application of quantitative and qualitative methods to solve relevant problems and predict outcomes, is coming to support and assist in simplifying HR challenging functions.

Analytics is the field that combines and integrates information technology, data science, statistical and quantitative methods, and computer-based models. There are four types of analytics, based on the questions they answer: descriptive (what happened), diagnostic (why something happened), prescriptive (what is likely to happen), and predictive (define actions to eliminate a future problem or specify a promising trend) (Schwarz et al., 2014). Although organizations have been using advanced data analytics in other areas such as marketing, sales, and finance (Bi & Cochran, 2014), their use in the field of Human Resources Management is still limited (Ekawati, 2019). From "How to Measure Human Resources Management" in the early 1900s, data analysis in the field of Human Resources is focused today on the prediction of employee behavior. The terms of People analytics and HR analytics are mutually used since they referred to the statistical analysis of employment data. People analytics is oriented on improving employee experience and well-being and focuses on people and the impact they create inside the company. The performance of any organization is also measured by having happy employees. The effect of having happier employees is mainly to make them work harder, work better and, generally, to be more productive (Zelenski et al., 2008).

Gartner annual report² introduced the term Augmented analytics in 2017 and it claimed that it will be the "future of data analytics". Augmented analytics refer to the procedure where data is automatically taken from data-sources, scrubbed, and analyzed, and published in a report using Natural Language Processing (NLP). The final report is understandable and ready to use by managers. In the context of the exponential flow of data (big data), augmented analytics is a promising solution to optimize the use of these data for decision-making by bringing automation to the complete analytics cycle (Prat, 2019). The term Augmented Analytics is still rarely found in literature. Watson (2017) and Gartner report are the first studies that referred to Augmented Analytics as an AI-powered Analytics and focused on data analysis automation. Prat (2019) uses the term AA and connects it with the 7-stage cycle. This automation will be achieved through the combined use of all the above mentioned technologies.

However, a remarkable increase in the literature for the topic of HR/People analytics is observed. The use of Neural Networks for the prediction in Talent Management and Employee Turnover studied by Goonawardene et al., (2010) and Sexton et al., (2005), while Machine Learning approaches for Employee recruitment, and NLP method is used for Resume Analysis by Pessach et al., (2020) and Zimmermann et al., (2016).

Finally, despite the fact that BI is directly influenced by new technologies, such as Neural Networks, Machine Learning, and Natural Language Processing, the complete automation of data analysis is still a focus area for both researchers and practitioners (Chen et al., 2012).

² <https://www.gartner.com/en/conferences/apac/data-analytics-india/gartner-insights/gc-augmented-analytics>

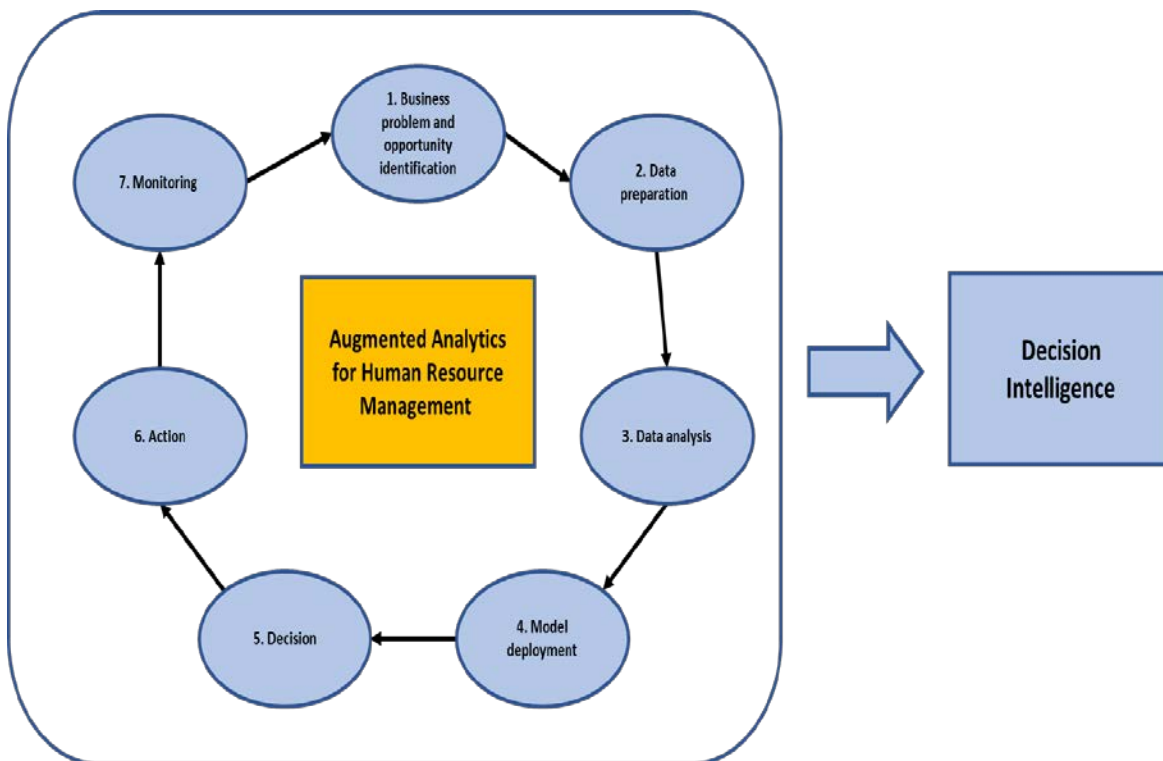
THE LIFE CYCLE OF AUGMENTED ANALYTICS FOR HUMAN RESOURCE MANAGEMENT

According to (CIPD, 2013), Analytics is an essential tool that can be used by the HR professionals, offering them a route to increase the impact of the HR functions for the entire firm. Data contained in HR records usually include information about existing employees (employment records, talents and competencies, formal educational skills, and demographic data), applicants and rejected applicants (Angrave et al., 2016).

In this section, an attempt is made to explain the proposed approach (the use of AA in HRM), describe the requirements for every step of the proposed seven-phase cycle, and conclude how this model could become a very helpful tool supporting Decision Intelligence.

Based on the CRISP-DM process model (Shearer et al., 2000), previous studies have presented different analytics cycles and models to describe every phase of processes (Seddon et al., 2017; Storey & Song, 2017). In this research, the seven-phase cycle of Prat (2019) is adopted as the basis, transforming every step according to concepts, needs, advantages, and disadvantages of HR (Figure 1).

Figure 1. Augmented Analytics Cycle for Human Resource Management



The first phase of the cycle is the Business problem and opportunity identification. This is an initial step for the cycle, which can be, at the same time, the last step, as data from the previous stages are coming back as feedback. In the case of big data, an automated system can collect much more information than people and reduce the processing time. Employees' data is often sensitive to personal data and firms need to adapt to existing regulatory procedures. However, the data could come from another cycle, but the final definition of Human Resources problems should come from the managers. As the identification of the problem is a matter of both the culture of the business and the instinct of the managers, there is a lack of confidence in the automated process as the human perspective decreases.

In the second stage, Data preparation for HR is expensive due to the types of data, as they originate from humans, so a result of automated cleaning is a risky choice. However, the reduction of time, the protection of personal data, and the conservation of the anonymity of these are the advantages of this step. Then, in the Data Analysis stage, the use of different types of data for analysis (text, numerical) and visualization can provide an advantage, which is also legally and ethically challenging. Nevertheless, new legal and ethical challenges are transforming the future of big data in many industries, including anonymization, protection of human subjects, fairness, and data protection.

At the next step (Model Deployment), HR requires cooperation between the IT and the management, which usually is not productive. So, it is very important the tools that will be used to be known from both sides in order to reduce this miscommunication. Further, in the Decision phase, managers do not support nor trust the automated analysis of the HR related data and, generally, oppose the idea any form of technological solutions to replace them and their judgment.

Therefore, the final decision, at least in critical situations, is based on managers' own judgment and experience, which is usually working better than an automated decision-making system.

In the Action stage, a solution at the HR department for time and workload reduction of employees is the use of conversational AI systems to answer employees' questions. The disadvantage of these applications is that as much as they facilitate the employees of the department they remove the meaning of the anthropocentric and personalized approach.

In the last step (Monitoring), the progress of the decisions that has been taken in the previous steps is monitored, while their impact on employees' satisfaction and productivity and other elements of the initial problems is continuously observed. Those elements are measured with data collected from different sources and take into account various emotional and psychological factors. Some sensors monitor how often employees are at their desks, or how long they go without speaking to each other. Those sensors can be a distraction or create privacy concerns.

From the above advantages and disadvantages of every step, it is recognized that IT technologies could improve the analysis of HR processes. The success of Decision Intelligence is determined by the combination (alignment) of the human factors and the ability of the business to adopt and utilize the appropriate technologies of the fourth Industrial Revolution.

CONCLUSIONS

In this paper, we examined the role of Augmented Analytics in Human Resource Management, highlighting some of the main advantages and disadvantages emerged during the Analytics Cycle. The main conclusion is that the success of every automated system is based, to a large extent, on the technology to be used. People analytics are being people-focused automated processes that will improve that anthropocentric feature. Development, management, and maintenance of these systems could enhance the decision-making processes and offer increased Decision Intelligence to firms.

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Analytics of Portfolio Selection Based on Distributions of Max Entropy Frontier

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Abstract

Traditionally the Mean-Variance approach introduced by Markowitz (1952) is the classical portfolio selection theory. By the investors, the naïve equal weights portfolio or $1/N$ is very old, simple, and occasionally successful strategy. It is also known that equal weights derived mathematically as optimum solution of max entropy principle. In this paper the portfolio of N assets represented in an entropy chart with expected portfolio return as horizontal axis, the normalized entropy of portfolio weights in vertical axis as measure of portfolio diversification. The max entropy distribution of portfolio asset weights subject to expected return determines an efficient frontier of portfolio Return-Entropy. Each point of this max entropy curve represents a specific geometrical distribution of portfolio assets weights, the solution of a nonlinear constrained optimization problem. Introduced the equivalent of Sharpe ratio to Return-Entropy efficient frontier, the Entropic Return Index. An illustrative application to a 10 stocks portfolio of NYSE and Nasdaq indexes is used to examine the out of sample performance of Entropy-Return efficient frontier. The relation of proposed approach with naïve equal weights ($1/N$) discussed in the framework of Jaynes max entropy principle. Our real data application shows that Entropic Return Index portfolio is possible to outperform both Mean-Variance and equal weights portfolios.

KEYWORDS

Portfolio Selection, Max Entropy Principle, Equal Weights Portfolio, Nonlinear Constrained Optimization, NYSE and Nasdaq indexes

INTRODUCTION

The out of sample superior performance of “naïve” $1/N$ portfolio is well known to investors and researchers [DeMiguel et al, 2007]. This superiority explained partially by the best diversification succeeded using equally weighted asset allocation in contrast to Mean-Variance (M-V) methodology [Markowitz, 1952], where the allocation is based on risk minimization measured by Variance of assets.

The idea of entropy proposed by Philippatos and Wilson [1972] as alternative risk measure to replace assets variance in the classical Mean-Variance approach. Because the allocation weights have similar properties of probabilities, entropy of portfolio weights suggested [Bera and Park, 2008] to solve the portfolio diversification problem [Choueifaty et al, 2013]. This approach presented with emphasis in the max entropy $1/N$ portfolio who empirically is attractive to investors. The diversification based on the allocation weighs sometimes called “nominal” diversification of assets to differentiate from other well-known ideas of investment diversification [Kolm et al, 2014]. Typically, an investment diversification succeeded including assets from different geographical exchanges, commodities, currencies, real estate, etc.

Applying max entropy principle, introduced by Jaynes [1957, 1963], main result is that $1/N$ (uniform) is the max entropy distribution, when the maximum uncertainty exists in a system. Jaynes also presented the solution (distribution) when there is information of the form an observed condition for the mean value of the system components. This definition of information entropy suggested by Shannon [1948] who in his famous paper includes a chart of entropy for a system with 2 possible states.

In this work we start from this 2 cases chart of Shannon and extended to N cases (assets) by computing the associated max entropy curve of portfolio weights. The resulting max entropy curve is the solution of a constrained optimization (max entropy of weights with respect to expected portfolio return). This curve in a portfolio return-normalized entropy chart is similar to Mean-Variance (M-V) efficient frontier curve of Markowitz [1952]. Using the investor utility on portfolio return and diversification is possible to improve the return of $1/N$ naïve portfolio. An Entropic Return Index introduced, like Sharpe ratio used in Mean-Variance approach [Sharpe, 1966].

The opportunity to improve the $1/N$ portfolio is the main goal of this work. The proposed max entropy frontier portfolios evaluated by an illustrative application on a real dataset of 10 stocks. Using Backtest demonstrated that max entropy diversification frontier portfolios perform better in out of sample period than equally weighted and M-V portfolios.

The remain of this paper organized as follows: In section 2 presented the max entropy frontier of portfolio weights selection starting from the two assets case, in section 3 the use of investor utility to introduce the suitable optimization

index, in section 4 an illustrative example with real dataset of 10 stock assets from NYSE and NASDAQ presented to exhibit the out of sample performance. Some concluding remarks in section 5 closes this work.

PORTFOLIO OPTIMIZATION BY MEAN-VARIANCE AND MAX ENTROPY

A portfolio is an allocation of invested capital to N assets A_1, A_2, \dots, A_N with returns R_i $i=1, 2, \dots, N$. The investor decision is the selection of asset weights W_i , $i=1, 2, \dots, N$. Practically investor objective is to maximize the selected portfolio performance, e.g. the expected portfolio return R_p defined by:

$$R_p = W_1 R_1 + W_2 R_2 + \dots + W_N R_N \quad (1)$$

a weighted average of assets returns R_i . Note that in portfolio return definition only the weights W_i and returns R_i directly involved. Because assets return R_i may vary over time, the variance of portfolio return $\text{Var}(R_p)$ also is a function of assets variances $\text{Var}(R_i)$ defined by:

$$\text{Var}(R_p) = \sum_{i=1}^N W_i^2 \text{Var}(R_i) + \sum_{i,j=1}^N 2W_i W_j \text{CoVar}(R_i, R_j) \quad (2)$$

Where $\text{CoVar}(R_i, R_j)$, $i \neq j$ are the Covariances of assets returns.

Statistically for the returns R_i of N assets, the Variance $\text{Var}(R_i)$ of asset i is a measure of risk. If the returns of two assets are negative correlated then portfolio risk (variance) decrease, the possible loss from the one asset is reduced by the possible gain of the other. By this statistical property, a portfolio based on non-correlated or negatively correlated assets can have variance (risk) lower than individual assets risk. This is the theoretical basis of Mean-Variance analysis to reduce the portfolio investment risk.

The portfolio diversification, e.g. investing your capital in different asset classes and securities in order to minimize the overall risk of the portfolio, measured by portfolio assets weights W_i entropy. The information entropy suggested by Shannon [1948], for portfolio weights defined by:

$$H(W_i) = -k \sum_{i=1}^N W_i \ln(W_i) \quad (3)$$

The entropy H maximized when the weights W_i are equal $W_i=1/N$, as introduced by Jaynes [1957] by the max entropy principle. For the portfolio problem this is the "naïve" equal weights or $1/N$ solution. By the investor point of view, if there is uncertainty of assets returns, investor choose to invest equally (equal weights) to each of available (selected) asset. Jaynes also introduced that if some information is available the problem is a constrained optimization of max entropy by transforming the information to an appropriate constraint.

Both Mean-Variance approach and Max Entropy approach are constrained optimization problems. By M-V the portfolio selection problem is a minimization of risk measured by the variance of portfolio $\text{Var}(R_i)$, by Max Entropy is a maximization of diversification measured by the weights of portfolio W_i entropy:

Min Variance (Risk):

$$\min_{W_i} \text{Var}(R_p)$$

Subject to constraints:

$$\sum_{i=1}^N W_i = 1 \quad \sum_{i=1}^N W_i R_i = R_p$$

Max Entropy (Diversification):

$$\max_{W_i} \sum W_i \ln(W_i)$$

Subject to constraints:

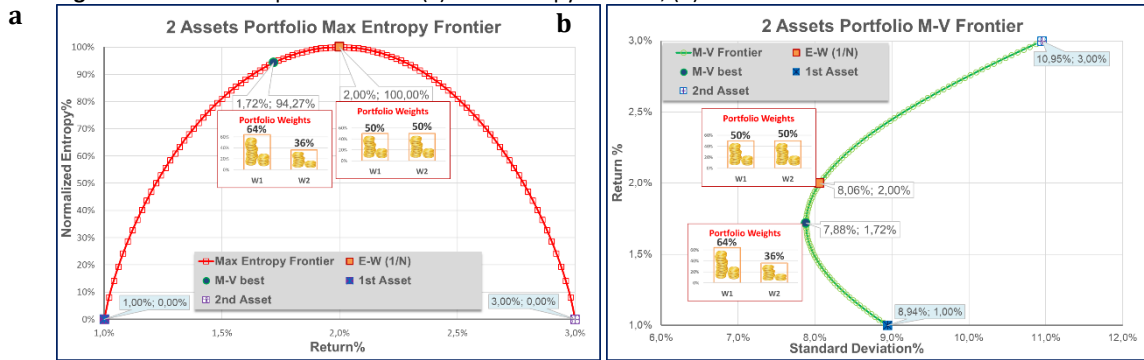
$$\sum_{i=1}^N W_i = 1 \quad \sum_{i=1}^N W_i R_i = R_p$$

In both cases the first constraint is the assets weights equal to 1 (also required W_i positive for no short selling case), e.g. the allocation of all invested capital to selected assets for non-short portfolio. The second constraint set the desired return of portfolio R_p , to construct the frontier of portfolios, portfolio return R_p varies from asset with minimum return R_1 to asset with maximum return R_N , if the N assets ordered by their return R_i . Thus, the frontier of portfolio it is a curve that shows the optimum portfolio risk (standard deviation) or diversification (entropy) for the associated value of portfolio return R_p .

The case of 2 Assets Portfolio Max Entropy Frontier

In Fig. 1(a) presented the max entropy frontier (red curve) which is the entropy curve presented by Shannon (1948). The original Shannon chart (Fig. 7 p. 20 of 1948 paper) use the probability p in horizontal axis and entropy H (Bits) in vertical axis, "... Entropy in the case of two possibilities with probabilities p and $q=1-p$ ". In our case the horizontal axis is the portfolio return R_p and the normalized entropy H in vertical axis. Thus, horizontal axis values start from 1st asset return (where $W_1=100\%$, $W_2=1-W_1=0\%$) and ends to 2nd asset return (where $W_1=0\%$, $W_2=100\%$). Between those 2 "extreme" portfolios there are shown 99 portfolios (points) of the form $W_1=X\%$, $W_2=100\%-X\%$ for $X=1\%, 2\%, 3\%, \dots, 99\%$, (step 1%).

Figure 1: The 2 Assets portfolio case: (a) Max Entropy Frontier, (b) M-V Frontier

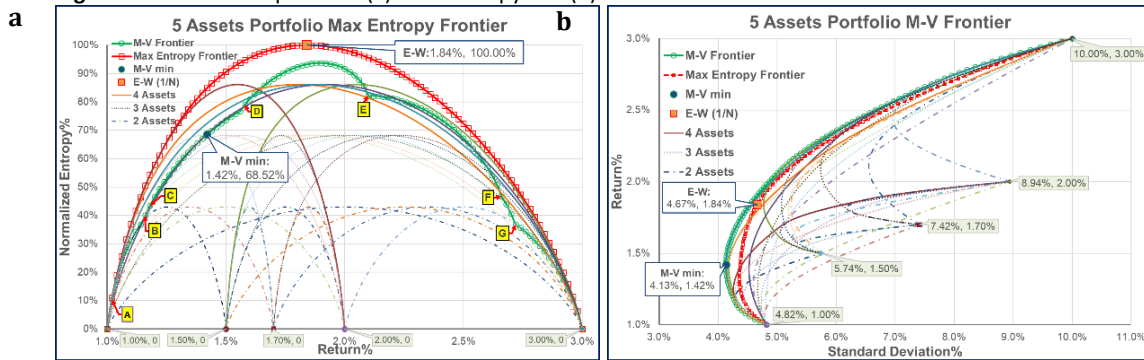


As is shown in fig. 1(a) the Mean-Variance minimum risk of Markowitz approach is on the left of Equally Weighted (1/N) portfolio, is not included in max entropy efficient frontier because has both lower Return and Lower Entropy. In fig. 1(b) it is shown that 1/N portfolio is included in the Mean-Variance (M-V) efficient frontier because has higher return (but also higher risk), the green curve is the whole M-V frontier.

The Case of 5 Assets Portfolio Max entropy Frontier

In the case of 2 assets portfolio the max entropy curve-frontier is always symmetrical around the mean of returns. Increasing the number of assets, the entropy curve is not always symmetrical, depends on the value of assets returns skewness. In fig. 2(a), below the red max entropy curve, there are sub-optimal entropy curves (with lower entropy-diversification) of fewer than 5 assets combinations. The number of those entropy curves calculated by the formula of statistical combinations: $C_4^5 + C_3^5 + C_2^5 = 5 + 10 + 10 = 25$. Each curve represents a combination of 4,3,2 assets of the total 5 assets. The max entropy value of those curves calculated by $\ln(k)/\ln(5)$ where k is the number of portfolio assets, e.g. for 4 assets is $\ln(4)/\ln(5) = 86,14\%$ meaning that if only 4 of the 5 available assets used in a portfolio then maximum entropy (diversification) is 86.14% of the max entropy (diversification) 100% of 5 assets portfolio. The green curve in fig 2(a) is the curve of M-V frontier portfolios curve shown in Return-Entropy axes, consists of several parts of parabolic curves. The points A,B,C,D,E,F,G indicates were the synthesis (included assets) of optimum M-V portfolio changes.

Figure 2: The 5 Assets portfolio (a) Max Entropy and (b) M-V frontier



In fig. 2(b) presented the M-V frontier (green curve) of 5 assets portfolio. Also, the sub-optimal curves are shown for combinations of fewer than 5 assets, it is critical to observe that typically those sub-optimal curves have parts on M-V frontier. The M-V frontier includes many parts of fewer than 5 assets portfolios.

UTILITY OF M-V AND MAX ENTROPY PORTFOLIOS

In both portfolio selection approaches the best portfolio is a particular “point” of the whole frontier, positioned on min risk (standard deviation) or max diversification (entropy) of selected assets. It is attractive for the investor to find portfolios with higher returns than the best. This analysis with both return (profit) and standard deviation (risk) or entropy (diversification) typically performed using the investor utility approach [Yang et al, 2017].

In the classical M-V analysis the Sharpe ratio (Return/Variance) [Sharpe, 1966] [Bailey et al, 2012] used to combine the two variables (criteria) return and variance (risk) of M-V frontier portfolios. Because the desired optimum is max return-min variance (risk) the ratio Return/Variance of the 2 criteria is the appropriate index to use. The Sharpe ratio measures

the performance of a portfolio, defined as the ratio of excess return of portfolio return ($R_p - R_{rf}$) divided by the standard deviation S of portfolio, where R_{rf} is the risk free return of an investment (usually in Treasury bonds):

$$S_a = \frac{R_p - R_{rf}}{S}$$

In Return-Entropy analysis of Max Entropy, with both optimum at max (entropy and return) an appropriate index is the product of return and entropy (R^*H). Because the normalized entropy values are in the closed interval $[0,1]$, the index behaves as an adjustment of return R . Thus, we call it Entropic Return (E.R.) Index. The Entropic Return Index (E.R.) of a specific portfolio with return R_p and entropy H_p defined by:

$$E.R. = R_p * H_p$$

In fig. 2(a) of max entropy curve points (portfolios) with higher Entropic Return located on the right side of 1/N portfolio (top of the red curve). In fig. 2(b) of M-V curve points (portfolios) with higher Sharpe ratio located on the upper side of M-V min portfolio (most left-side of the green curve).

AN ILLUSTRATIVE EXAMPLE OF 10 ASSETS PORTFOLIO

A data set of 10 stocks from NYSE and NASDAQ used as an illustrative example: General Electric (GE), Exxon Mobil (XOM), PG&E (PCG), International Business Machines (IBM), Cisco Systems (CSCO), AT&T (AT&T), The Coca-Cola Company (KO), Bristol-Myers Squibb (BMY), Apple Inc (AAPL), Amazon.com (AMZN).

Historical monthly data of the period 2006/Jan-2015/Dec, a total of 120 months, used as "BackTest". Calculated the average monthly return R and standard deviation $\sigma(R)$ of each stock. The out of sample data was of the period 2016/Jan-2018/Dec. 12-24-36 monthly data used to evaluate performance of portfolios in 1-2-3 years investment horizon. All data downloaded from Yahoo Finance website, where is available to anyone interested: <https://finance.yahoo.com>. In table 1 the stocks ordered by their average monthly return of the period 2006-2015 in ascending order.

Table 1: Synthesis (Assets Weights %) and Statistics of 4 Compared Portfolios

	<i>Asset (Stock)</i>	<i>Entropic Return</i>	<i>Sharpe ratio</i>	<i>1/N portfolio</i>	<i>M-V Best</i>	
Portfolio Synthesis	GE	3.7%	0.00%	10%	0.00%	
	XOM	3.9%	0.00%	10%	13.75%	
	PCG	4.4%	5.89%	10%	31.58%	
	IBM	4.4%	0.00%	10%	24.62%	
	CSCO	4.7%	0.00%	10%	0.00%	
	AT&T	5.0%	0.00%	10%	9.42%	
	KO	5.6%	13.72%	10%	13.61%	
	BMY	9.1%	34.09%	10%	7.02%	
	AAPL	24.6%	25.96%	10%	0.00%	
	AMZN	34.6%	20.33%	10%	0.00%	
	<i>sum</i>	100%	100%	100%	100%	
Historical Period	Entropy H	82.89%	64.29%	100%	72.19%	
	R	1.97%	1.90%	1.19%	0.81%	
	σ	6.03%	5.13%	4.14%	3.04%	
	Sharpe ratio	29.30%	33.08%	24.01%	19.94%	
	H*R	1.63%	1.22%	1.19%	0.58%	
Out of Sample	12	R	1.05%	0.39%	1.10%	1.52%
		σ	(4.46%)	(4.50%)	(3.47%)	(3.23%)
	24	R	1.62%	1.22%	0.77%	0.42%
		σ	(3.65%)	(3.99%)	(2.73%)	(2.99%)
	36	R	1.19%	0.857%	0.142%	-0.44%
		σ	(4.75%)	(4.64%)	(3.42%)	(3.90%)

Evaluated the performance of 4 different portfolios: 1) proposed max Entropic Return index, 2) the Sharpe ratio best, 3) equal weights (1/N) "naïve" (most diversified) and 4) Mean-Variance (min risk). The synthesis of each portfolio (assets weights in each portfolio) presented on the upper part of table 1. In our case observed the familiar of M-V approach problem, concentration on few assets, is present in both Sharpe ratio and M-V min portfolios. The weights of Entropic Return seem to follow a geometrical series.

The results on "out of sample" period for 12, 24 and 36-months horizon also presented on table 1. Initially for short time horizon of 12 months best portfolio is the M-V portfolio with both higher return 1.52% and lower risk ($\sigma=3.23\%$). But in the 24 months horizon best performance portfolio is the proposed Entropic Return portfolio with return 1.62%. Also, in 36 months horizon Entropic return outperforms the other portfolios with return 1.19%. In both cases of 24- and

36-months horizons Entropic Return has the higher return but not the minimum risk, measured by standard deviation σ . Higher return of an investment portfolio is associated with higher risk. It agrees with common sense: *in order to succeed higher return, it is needed to accept higher risk.*

Looking at the “Historical Period” part of table 1 it is shown, as expected, that every one of the 4 portfolios is the best on his criterion of construction. But the Entropic Return Index portfolio has the maximum return (1.96%) in the historical period of 120 months. The entropy is 82.89% less than 100% of 1/N portfolio, and risk almost double of M-V best (min risk) portfolio.

Finally the answer to the main question of this paper: *it is possible to beat the 1/N portfolio out of sample good performance?* Is positive. We present evidence (a specific stocks dataset) where this can be done based on the same optimization (entropy of weights) and investor utility.

CONCLUSIONS

For the 1/N portfolio and max entropy: It is possible to use the max entropy approach to overcome the “naïve” equal weights portfolio performance by calculating the whole max entropy frontier and then the max Entropic Return portfolio.

For the investor: The proposed Entropic Return index portfolio increase the expected return of the investor but also increase the risk. It is the equivalent to Sharpe ratio portfolio in the M-V approach. The exponential form of assets weights is probably surprising to investors but is a characteristic of max entropy approach solutions, Jaynes [1963] explain the necessity of geometrically distributed weights.

For the M-V methodology: It is well known that has certain disadvantages (like concentration on few assets) but remain a productive idea. Help us to discover and apply new methodologies on the “portfolio problem”, methods based on mathematics, statistics, and analytics novelties [Kolm et al, 2014].

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Session 12:
Multiple Criteria Decision Analysis
chair: Athanasios Vavatsikos

A Framework for Implementing PROMETHEE II in GIS-assisted Suitability Analysis

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Abstract

Site selection, site suitability, or land use suitability analysis aims to investigate the degree of preference of a land use type to all the feasible locations in the examined area. Its role is vital to assist in planning processes and investment decisions for both the public and private sectors. It is widely accepted that suitability analysis consists of a multicriteria analysis problem since the most appropriate sites are identified through the evaluation of a large number of alternative locations and involve multiple usually conflicting criteria and constraints. Multicriteria decision-making methods (MCDM) are widely applied as the most appropriate tools for site screening problems. The spatial nature of suitability analysis resulted in the development of synergies of MCDM methods with Geographic Information Systems (GIS) due to their capacity to manage, handle and retrieve spatially related data types. However, and beyond their renowned abilities, GIS implementation lack of appropriate tools for handling decision maker's preferences. As a result, a discrete research field of Spatial Multi-Criteria Decision Analysis (SMCDA) has emerged aiming to combine MCDM and GIS overlay map layering capabilities. Although numerous amount of research papers has been published, the presence of outranking relations methods (e.g. PROMETHEE, ELECTRE) remains scarce when large raster datasets are involved in the analysis due to computational limitations derived from the need to compare in pairs every candidate location. To overcome these limitations the current paper presents a framework that enables PROMETHEE II implementation in raster-driven GIS-based land suitability analysis. The proposed framework provides the guidelines for a variety of net preference flows estimators using both total and per criterion net preference flows for a sample of alternatives. Afterwards, these estimations are interpolated for every examined location implementing Tobler's first law of geography.

KEYWORDS

Suitability Analysis, GIS, MCDA, PROMETHEE II.

INTRODUCTION

Taking advantage of modern Geographical Information Systems (GIS) capabilities for efficient and sophisticated handling of spatially related data, GIS-based suitability analysis is a major field of interest among GIS analysts (Collins et al., 2001). With an emphasis on the working environment, GIS-based suitability analysis can be vector or raster-driven. In vector-driven procedures, alternative sites are defined as records in a spatially related database while the decision matrix (i.e. alternatives performance to the analysis criteria) is stored in its fields. On the contrary, in raster-driven analysis alternative locations or candidate sites consist of an image where each one of its pixels is considered as a discrete alternative location. As a result, the decision matrix is formed by a set of images where each one of them facilitates alternatives performances for a given criterion. The ability of GIS software packages to support geoprocessing tools such as overlay procedures led both scientists and practitioners to often refer to them as Spatial Decision Support Systems (SDSS). However, Boolean overlays do not provide procedures to evaluate the suitability of sites falling within feasible areas (Carver, 1991). To overcome these limitations relative suitability consists of the field of synergy between Multi-Criteria Decision Analysis (MCDA) and GIS aiming to develop procedures that allow spatially related data and value judgments combination to obtain information for decision making.

However, outranking methods incorporation into GIS environments is primarily limited to vector-driven analysis with a relatively small number of alternatives evaluated. For large raster datasets with an excessive number of alternatives, their implementation faces computational limitations (Marinoni 2006). To enable outranking method implementation in GIS-based raster-driven suitability analysis, Joerin et al. (2001), Marinoni (2005 and 2006), Chakhar&Mousseau (2008), and Lin (2008) proposed frameworks that aim to reduce the computational load required for alternative pairwise comparisons. Joerin et al. (2001) proposed the formation of homogenous zones using a closeness relationship function based on rough set theory. In the same context of aggregating spatial units, Marinoni (2005, 2006) proposed a deterministic and stochastic approach that is implemented in regular or irregular zones. Lin (2008) identified landslide-prone areas using a self-organizing map (SOM) neural network, and Chakhar&Mousseau (2008) obtained alternatives

by estimating homogenous spatial units combining both ELECTRE TRI-based overlay procedures and similarity aggregation processes. Recently, concerns related to the loss of information are overpassed to several research papers (e.g. Çetinkaya et al, 2018; Inamdar et al, 2018). A common practice to all the above approaches is the incorporation of PROMETHEE II method in the GIS environment by aggregating the per criterion performances through rating attributes row data using crisp rating scores. The paper at hand proposes a framework based on PROMETHEE method to overcome computational limitations of the outranking relations methods when implemented to GIS-based raster-driven suitability analysis. In particular, the proposed framework reduces the computational load by taking into consideration a sample dataset in the examined area, and then the results derived by PROMETHEE implementation are interpolated to every candidate location (pixels) in the examined area employing Tobler's first law of geography.

MODELS AND METHODS

PROMETHEE Methods

Short Description

PROMETHEE (Preference Ranking Organization Methods for Enrichment Evaluations) is a set of methods that are used in Multi-Criteria Decision Analysis (MCDA). PROMETHEE belongs to a family of outranking methods and has been applied to several application fields (i.e. industrial location selection, manpower planning, water resources, investment evaluation (Brans and Mareschal 2005, Behzadian et al. 2010). It was developed by (Brans and Vincke 1985) and provides alternative scenarios ranking based on the deviations of their performances to the analysis criteria. Technically this is achieved by forming pairwise comparison matrices which are then normalized according to decision makers preferential system. As a result, PROMETHEE estimates the degree that denotes how every alternative outranks or is outranked by the others through the estimation of positive Φ^+ and negative Φ^- preference flows (Equation(1), Equation (2)). Then Φ^{net} preference flow is derived according to Equation (3). As soon as net outranking flow $\Phi^{net}(\alpha_i)$ is estimated for each one of the examined alternatives, the complete ranking is obtained using the preference structures P and I which denote strict preference or indifference respectively (Equation(4), Equation(5)).

$$\Phi^+(a_i) = \frac{1}{n-1} \sum_{k=1}^m \pi(\alpha_i, \alpha_k) \quad (1) \quad \Phi^-(a_i) = \frac{1}{n-1} \sum_{k=1}^m \pi(\alpha_k, \alpha_i) \quad (2)$$

$$\Phi^{net}(\alpha_i) = \Phi^+(a_i) - \Phi^-(a_i) \quad (3) \quad \alpha_i P \alpha_k \text{ if } \Phi^{net}(\alpha_i) > \Phi^{net}(\alpha_k) \quad (4)$$

$$\alpha_i I \alpha_k \text{ if } \Phi^{net}(\alpha_i) = \Phi^{net}(\alpha_k) \quad (5)$$

Alternatives' Profile

Apart from the straightforward implementation of the PROMETHEE method to estimate the net preference flows using the above equations, a special property of the method is of great interest for applying the method in the GIS environment. Brans & Mareschal (2005) introduced the term of weight free per criterion flows (Φ_j). Positive (Φ_j^+) and negative (Φ_j^-) weight free per criterion flows are obtained according to Equations (6) and (7). As a result, the per criterion net flow (Φ_j^{net}) is obtained using Equation (8), while, the overall net flow of an alternative can be obtained as the weighted average of the per criterion Φ_j^{net} Equations(9), (10). Thus, the suitability index is estimated in terms of weighted average and the analysis gains credit by the advanced overlay operators supported by modern GIS software packages.

$$\Phi_j^+(x_i) = \frac{1}{m-1} \sum_{k=1}^m P_j(a_i, a_k) \quad (6) \quad \Phi_j^-(x_i) = \frac{1}{m-1} \sum_{k=1}^m P_j(a_k, a_i) \quad (7)$$

$$\Phi_j^{net}(x_i) = \Phi_j^+(a_i) - \Phi_j^-(a_i) \quad (8)$$

$$\Phi^{net}(x_i) = \sum_{j=1}^n w_j \Phi_j^{net}(a_i) \quad (9) \quad \Phi^{net}(x_i) = \sum_{j=1}^n w_j \Phi_j^+(a_i) - \sum_{j=1}^n w_j \Phi_j^-(a_i) \quad (10)$$

Spatial Interpolation-Inverse Distance Weighting (IDW)

IDW is a well-known spatial interpolation technique that allows values predictions at unmeasured locations based on the already known measurements at certain locations. Based on Tobler’s first law of geography according to which ‘everything is related to everything else, but near things are more related than distant things’ (Tobler 1970), IDW assumes that the unknown values can be predicted as a function of the distance from the measured values (Shepard 1968). IDW is also referred to as an exact interpolator because it predicts a value identical to the measured value at a sample location (Johnston et al. 2001). Equations (11),(12) and (13) present the general formula for IDW interpolation where $z(x, y)$ is the predicted value at location with coordinates (x, y) , t is the number of the measured-known sample points surrounding the prediction location, λ_i are the weights assigned to each measured-known point z_i at location (x_i, y_i) , d_i is the Euclidean distance to the two-dimensional space that separates (x, y) and (x_i, y_i) and p is an exponent for handling the impact of z_i on z (Shekhar 2017). As a method is capable of handling the impact of closest locations to the final estimated prediction.

$$z(x, y) = \sum_{i=1}^t \lambda_i z_i \quad (11)$$

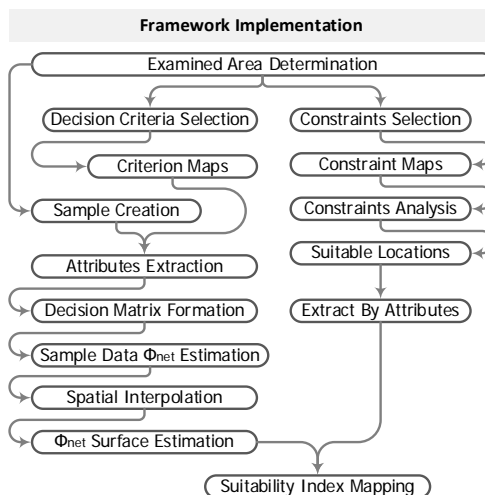
$$\lambda_i = \frac{(1/d_i)^p}{\sum_{i=1}^t (1/d_i)^p} \quad (12)$$

$$\sum_i \lambda_i = 1 \quad (13)$$

PROPOSED FRAMEWORK

The proposed framework is an attempt to overcome computational limitations of the PROMETHEE method by reducing the computational load of the method and assuming that Tobler’s law can be extended to preferences in the same manner as with measurements. Thus, preference flows Φ can be estimated for a sample of locations and then continuous preference flows surfaces can be generated to the examined area using spatial interpolation techniques such as IDW. Figure 1 presents the proposed framework’s sequence of steps aiming to estimate Φ^{net} surfaces that provide a measure of suitability for every candidate location and for a certain land use type. In contrast to utility-based approaches, PROMETHEE-based suitability estimation can be derived in parallel with constraints analysis since outranking relations methods evaluate alternatives based on their performance’s deviations and not according to their absolute values to the analysis criteria.

Figure 1. Proposed framework



COMPUTATIONAL OPTIONS

From the computational point of view, the proposed framework enriched by the PROMETHEE property of the per criterion unweighted flows estimation can be implemented using at least four computational options. Even though they all reach the same result, every option produces a variety of intermediate preference mappings that provide useful insights into the analysis and assist decision makers in their attempt to reach coherent decisions. The first option (Option

1) is the most straightforward approach. Suitability index is derived by interpolating the estimated Φ^{net} of the sample dataset. In the second option (Option 2), Φ^{net} is reached as the difference between the Φ^+ and Φ^- interpolation surfaces. The third computational model (Option 3) interpolates the per criterion unweighted net preference flows Φ_j^{net} and suitability index is derived as the weighted summation of the interpolation surfaces. Finally, Option 4 estimates the interpolation surfaces for the per criterion unweighted positive Φ_j^+ and negative Φ_j^- preference flows. Weighting summation allows the estimation of total positive Φ^+ and negative Φ^- preference flows and their subtraction provides the overall suitability index in accordance with Φ^{net} .

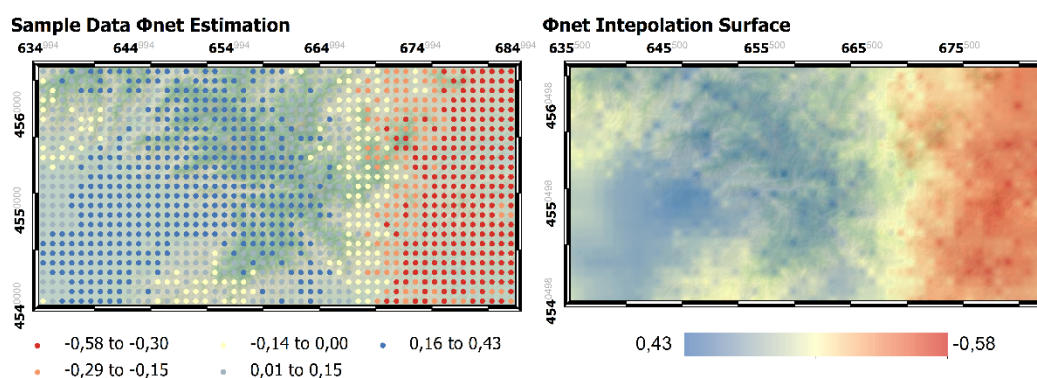
Table 1. Decision problem formation specifications

	Criterion 1	Criterion 2	Criterion 3	Criterion 4
Attribute	Dist. From Natura 2000 Areas (m)	Dist. From Settlements (m)	Dist. From Primary Road Network (m)	Slopes (%)
Criterion Type	Ascend	Ascend	Descend	Descend
Weights	35%	30%	20%	15%
Preference Function	Type III	Type V	Type III	Type V
Indifference Threshold	0	5.000	0	5%
Preference Threshold	10.000	10.000	5.000	15%
Min Observed Value	0,00	0,00	0,00	0,00
Max Observed Value	37.493	17.395	15.638	96

ILLUSTRATIVE EXAMPLE

The discussed spatial decision-making framework is presented using an illustrative hypothetical example where the suitability index for a given land-use type is performed using four decision criteria. The decision problem formation is presented in Table 1. The considered land use type gains advantage in areas that are as far as possible from environmentally protected areas belonging to zone A of the Natura 2000 protection network (Criterion 1). Also, remote areas to settlements or urban centers are considered more suitable (Criterion 2). Candidate locations accessibility is taken under consideration using the distance from the primary road network criterion map (Criterion 3). Earthmoving costs for flattening the examining area are taken into consideration using the slopes criterion map. As long as criterion maps have been obtained, a spatially uniform arranged points sample dataset has been created with a distance of 1km to both directions. Then criterion maps at the sample locations have been extracted and Φ^{net} has been estimated. The process has been finalized by implementing IDW to generate the Φ^{net} surface to the analysis spatial extent. Figure 2 presents Φ^{net} estimation at the sample locations and interpolation surface generation.

Figure 2. Analysis results



CONCLUSIONS

Efficient site selection and location is a matter of great importance since it enhances the planning process with sophisticated tools that allow efficient allocation of land use types and protects the planning process against failures related to inappropriate site selection. As a result, both relative and absolute GIS-based suitability analysis gained enormous attention to provide decision-making frameworks that assist coherent and rational decisions. Beyond the indisputable benefits derived by the synergy of GIS and MCDA methods, the presence of collaborations with procedures

that belong to the family of outranking relations methods remains scarce to the scientific literature. This is primarily owned by the fact that their implementation, especially when large raster datasets are involved in the analysis, face computational limitations. The current research proposes a framework to reduce computational load and extend PROMETHEE applicability in such cases combining GIS, PROMETHEE method and spatial interpolation models. The proposed framework takes advantage of the ability to perform absolute and relative suitability in parallel and it gains flexibility since a variety of computational models can be implemented aiming to obtain metrics for each criterion and transform data into actionable insights.

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Multicriteria evaluation with TOPSIS method for digital promotion in local alternative tourism sector

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Abstract

Although mass tourism contributes to economic growth and job creation, it also demonstrates side effects, such as deterioration of touristic areas due to imitation of imported cultural standards, transformation of areas of natural beauty into urban centers without local cultural character and environmental pollution. Mass tourism criticism has led to the development of alternative tourism, which is characterized by mild small-scale tourism and includes, among others, eco and cultural tourism, gastronomic/wine tourism and agritourism. An important factor in the promotion of alternative tourism is the development of contemporary ICT services. Finding a potential alternative tourist destination, generally unknown to the public, is now easier through online and social media services that spread personal travel experiences and provide information through addresses, photos, and videos of travel destinations. The Prefecture of Kavala gathers a wide range of forms of alternative tourism including eco-tourism in the National Park of Nestos Delta, sites of significant historical and archaeological importance, health and spa services, various sites of religious tourism and offers a wide range of agricultural products and a variety of forms of alternative coastal and marine tourism on the coasts of Kavala and Thassos. This paper aims to study and evaluate the enterprises that promote alternative tourism in this region qualitatively and quantitatively according to their digital characteristics used as criteria, based on the multicriteria method of TOPSIS. Finally, the optimum enterprises are identified and described to be used as a model with enhanced digital promotion. The findings of this study reveal the progress, the development and the perspectives of the local alternative tourism sector in the current competitive era, as well as the digital promotion rate in the sector.

Keywords: alternative tourism, multicriteria evaluation, TOPSIS method, digital promotion, prefecture of Kavala

INTRODUCTION

Mass tourism, in addition to its benefits, such as economic growth and job creation, also demonstrates side effects, such as deterioration of touristic areas due to imitation of imported cultural standards, transformation of areas of natural beauty into urban centers without local cultural character and environmental pollution (Andriotis, 2003). Mass tourism criticism has led to the development of alternative tourism, which is characterized by mild small-scale tourism and includes, among others, eco and cultural tourism, gastronomic/wine tourism and agritourism and produces less negative effects on destination areas, the environment and the population without reducing the positive economic impact (Christou, 2012).

Alternative tourism can include active tourism such as hiking and trekking, exploring, socializing with local population, even volunteer work and participating in archaeological excavations. The alternative tourism enthusiast does not wish to be considered as an ordinary customer or as a consumer. His travel destination can be an unexplored "virgin" area and is motivated by an idealized view of rural societies representing authentic cultural values. Alternative tourism

residence is of complementary type: Camping, local family hostels or rented houses of residents and small accommodation facilities, completely contrary to the concept of large hotels mass tourism. The organization of alternative tourism trips is carried out either by individuals or by non-conventional forms of travel organizations and the local community welcomes the visitor through a system of mutual reception and integration (social, economic, ecological) (Ed. Theobald, W., 2005).

Finding a potential alternative tourist destination, generally unknown to the public, is now easier through online and social media services that spread personal travel experiences and provide information through addresses, photos, and videos of travel destinations. Social networking technologies and platforms especially, play an important role in alternative tourism economy (Molz, 2013). Consequently, an important factor in the promotion of alternative tourism is the development of contemporary ICT services. The quality of the websites of enterprises operating in the alternative tourism sector is particularly important because it directly influences the perceived image of the destination and creates a virtual experience for the customer and user acceptance of websites is a critical success factor for e-commerce enterprises offering agricultural products (Andreopoulou et al., 2014).

As it is the case for Greece, most enterprises in alternative tourism sector in Kavala region are Small and Medium-sized Enterprises (SMEs). SMEs in Greece are using e-business not only to enable growth through extended and refined offerings but also to expand their markets and SMEs that have already adopted e-marketing applications may vary significantly in terms of the scope and extent of incorporating e-business applications into their business processes and benefiting from them (Tsekouropoulos et al 2013). Therefore, the benefits of E-marketing for SMEs operating in the alternative tourism sector play an important role in achieving their business goals as they provide a global reach for finding new markets. Furthermore, the lower cost of E-marketing can reach the right customers at a much lower cost than traditional marketing methods, its results are trackable and measurable and offers 24-Hour marketing, shorter lead times and, through personalization, provides targeted offers to customers according to their personal preferences (Tsekouropoulos et al., 2012).

The Prefecture of Kavala gathers a wide range of alternative tourism forms, a total of 15 as the digital map results demonstrate. A significant one is eco-tourism in the National Park of Nestos Delta, a wetland of enormous ecological importance for Greece, part of the Natura 2000 Network. There are sites of significant historical and archaeological importance, including among others the archaeological site of Dikili Tash, mainly a prehistoric settlement, dating to the Neolithic period and the Bronze Age. Other destinations are the castle of Kavala and the most recognizable monument of Kavala, its large arched aqueduct, known as "Kamares", built in the early 16th century, during the Turkish occupation, upon the remains of a Roman and a Byzantine aqueduct. The area of Kavala has been also a pole of religious tourism in recent years, using the historical course of Apostle Paul in Macedonia starting from Fillipi, where his prison and ruins of proto-Christian temples are preserved. It is an important tourist destination for Catholic Christians mainly from Italy, including even Vatican officials. X₂

Regarding agritourism, several estates and farms are operating either as guesthouses or as points of sale of agricultural products and offer guided tours of production and cultivation facilities. Also, there are several companies offering gastronomic and wine tourism services, with farms producing honey and beekeeping products, aromatic plants and wine-producing estates.

The Prefecture of Kavala demonstrates significant activity in forms of alternative marine tourism such as diving tourism and sailing tourism, provided by yachting companies in Kavala and Thassos island. Furthermore, there are mountaineering and speleology activities and high-quality thermal tourism services in the region, in the forms of clay therapy and hot springs natural pools. The region also offers conference tourism services.

This paper aims to study and evaluate the enterprises that promote alternative tourism in this region qualitatively and quantitatively according to their digital characteristics used as criteria, based on the multicriteria method of TOPSIS. Finally, the optimum enterprises are identified and described to be used as a model with enhanced digital promotion.

METHODOLOGY

The digital map was compiled by recording the websites of institutions and companies directly related to alternative tourism in the area of the Prefecture of Kavala and by their registration into a database according to the characteristics of 30 criteria for website evaluation.

Table 1. Characteristics of Alternative Tourism Enterprise websites

Variable	Criteria
X ₁	Contact information
X ₂	Available photographic / audiovisual material
X ₃	Information on the products/services offered
X ₄	Account available on social networks (profile)
X ₅	Online contact form
X ₆	Available local interest information
X ₇	Digital map
X ₈	Website update of new activities
X ₉	Providing information on various topics
X ₁₀	Providing information on relevant topics
X ₁₁	Useful links
X ₁₂	Third-party ads
X ₁₃	More than 2 languages available
X ₁₄	Possibility of sharing the website on social networks
X ₁₅	Search engine app
X ₁₆	Weather Forecast service
X ₁₇	Web site map
X ₁₈	Digital files available for download
X ₁₉	Calendar/clock app
X ₂₀	Ability to register visitors as members of the website
X ₂₁	Newsletter service
X ₂₂	Event calendar app
X ₂₃	Online Survey
X ₂₄	Holiday calendar
X ₂₅	Forum
X ₂₆	Website visitor tracker
X ₂₇	RRS service
X ₂₈	Live Web Camera
X ₂₉	Answers of FAQ (Frequently Asked Questions)
X ₃₀	Personalization of the website, security, detection of malicious actions

The criteria have the same weight and the multicriteria method of TOPSIS was applied to the dataset to identify the optimum enterprises. TOPSIS is widely used on studies regarding tourism sustainability (Liu et al. 2018) (Nilashi et al. 2019) and evaluating and ranking of tourism destinations (Goksu, 2014). This method was selected because it helps the decision-maker to solve evaluation problems and its most important characteristic is the fact that it is based on the rational of human choice (Andreopoulou et al. 2018). The optimum case should be within close distance of the Positive Ideal Solution – PIS (the solution with maximum benefits and minimum costs) and within long distance of the Negative Ideal Solution – NIS (the solution with minimum benefits and maximum) costs. Finally, the total ranking of the enterprises is presented according to their scores. As future research and extension to the current paper, total ranking will be applied with other multi-criteria methods such as PROMETHEE or VIKOR.

RESULTS

During the survey, 42 websites of state agencies and businesses were found in direct connection with alternative tourism in Prefecture of Kavala. The digital map was compiled by recording the websites of institutions and companies directly related to alternative tourism in the area of the Prefecture of Kavala and by their registration into a database according to the characteristics of 30 criteria for website evaluation.

Table 2 presents the results of the application of the TOPSIS method. CC index is calculated for each alternative tourism enterprise and it is used for the total ranking. Each alternative tourism enterprise with higher CC value is considered superior to the alternative tourism enterprises with lower CC value. According to the findings below, the CC values present a spectrum between 0,27525 and 0,71628 and that shows a difference between the first and the last alternative tourism enterprise in the total ranking.

Table 2. Total ranking of the Alternative Tourism Enterprises according to their website characteristics

	Alternative Tourism Enterprise	di+	di-	CCi
1	ATE9	0,01468	0,03705	0,71628
2	ATE1	0,02663	0,02965	0,52682
3	ATE5	0,02687	0,02943	0,52265
4	ATE3	0,02703	0,02928	0,51997
5	ATE2	0,02932	0,02699	0,47928
6	ATE10	0,03012	0,02609	0,46413
7	ATE26	0,03033	0,02584	0,46003
8	ATE33	0,03045	0,02571	0,4578
9	ATE12	0,03157	0,02432	0,43511
10	ATE43	0,03189	0,0239	0,42842
11	ATE42	0,03228	0,02337	0,41993
12	ATE31	0,0323	0,02334	0,41944
13	ATE23	0,03268	0,0228	0,41097
14	ATE39	0,03281	0,02261	0,40801
15	ATE36	0,03286	0,02255	0,40692
16	ATE37	0,03293	0,02245	0,40542
17	ATE19	0,03305	0,02226	0,40249
18	ATE30	0,03327	0,02193	0,39725
19	ATE15	0,03349	0,02159	0,39201
20	ATE16	0,03362	0,02139	0,3888
21	ATE25	0,03367	0,02132	0,38769
22	ATE29	0,03369	0,02128	0,38716
23	ATE28	0,03394	0,02089	0,38098
24	ATE13	0,03397	0,02083	0,38014
25	ATE21	0,03418	0,02049	0,37485
26	ATE40	0,0342	0,02046	0,37436
27	ATE27	0,03427	0,02034	0,37248
28	ATE22	0,03437	0,02018	0,36992
29	ATE7	0,03451	0,01993	0,36614
30	ATE17	0,03451	0,01993	0,36614
31	ATE20	0,03464	0,01971	0,36265
32	ATE32	0,03471	0,01958	0,36068
33	ATE24	0,03472	0,01957	0,36046
34	ATE8	0,03487	0,0193	0,35628
35	ATE4	0,03488	0,01928	0,35593
36	ATE18	0,03494	0,01917	0,35432
37	ATE34	0,0351	0,01887	0,34962
38	ATE38	0,03537	0,01836	0,34179
39	ATE14	0,0354	0,0183	0,34078
40	ATE11	0,03558	0,01796	0,33546
41	ATE6	0,0356	0,01791	0,33464
42	ATE41	0,03663	0,0157	0,29997
43	ATE35	0,03725	0,01415	0,27525

CONCLUSIONS

The results of the survey initially demonstrate that the region offers a wide range of forms of alternative tourism, represented by 15 corresponding activities. During the survey, 42 websites of state agencies and businesses were found in direct connection with alternative tourism in Prefecture of Kavala. The digital map was compiled by recording the websites of institutions and companies directly related to alternative tourism in the area of the Prefecture of Kavala and by their registration into a database according to the characteristics of 30 criteria for website evaluation. In the current competitive era, most of the alternative tourism enterprises in Kavala use internet technologies for their most effective promotion. According to the TOPSIS results, the optimum alternative tourism enterprise is identified and it can be used as a model with enhanced digital promotion (audiovisual material, information provision, social networking, online contact form, third-party ads, multilingual website, website map, calendar application, online survey, forum). Moreover, it is also concluded that there is room for significant development of the digital capabilities of the websites offered by alternative tourism products and services in the wider region of Kavala. Regarding the possible policy recommendations that derive from this study, it is apparent that alternative tourism enterprises must adopt new technologies to an even greater degree and invest in contemporary ICT services, upgrading their digital promotion and outlook in order to fully benefit from digital promotion in local alternative tourism sector.

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Attitudes and Behavior of Greek Teachers Towards the Implementation of Intercultural Practices

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Abstract

Globalisation, technology advancement, the influx of people and the freer movement of people have caused considerable social stress and unrest. Specifically, such changes are key determinants to the foremost significant issues of inclusion, tolerance to the others and respect to the different. In this context, education is a vital pedagogical tool to build up the attitudes and the behaviour of the educates. However, such personal development of personalities has undergone fundamental changes as well, which have been certainly framed in intercultural education. Recently intercultural education has gained great emphasis, enactment and activity due to a number of reasons: advancements in digital technology, freer and increased mobility among people worldwide, as well as migration to European countries, being all critical viewpoints of conceptualizing globalization. The research outcomes signified those practices' related to interculturalism and the necessity of applying them among educational communities. The surveyed educators' denoted the need of changes and/or taught adaptations regarding the existing curricula, while significant statistical correlations between demographic data and three interculturality factors were also addressed.

KEYWORDS

Intercultural Education, Intercultural Practices, Intercultural Competence, Correlation Coefficients.

INTRODUCTION

During the last decades the free movement of people within the European territory, as well as the technological advancements' spur in the field of communication, they resulted in adaptation of postmodern approaches to aid the communication of people with different linguistic and cultural backgrounds. Educational policies and schools units, as institutions, initiated a change in their monocultural viewpoint of policy makers; start negotiating about the concept of interculturalism. The intercultural concept, as it was coined in the US in the beginning of the 20th century, promised a better life creating the American dream. Nowadays, education stakeholders seem to favour assimilation. In that sense it seems necessary to find ways to raise intercultural awareness in schools and cultivate intercultural competence. As a result schools, as social institutions, and educational policies have to be associated with communication among people of differentiated cultural backgrounds. Therefore, an analysis of the term "intercultural" seems unavoidable since it is premised that a closer look at what intercultural education entails, it is offered in this analysis. Therefore, this study attempts to enhance our knowledge about ways under which the demonstration of quantitative and qualitative inquiries by educators who teach in the Greek public primary and secondary schools in West Attica, they could be developed.

LITERATURE REVIEW

Intercultural Education

A vast number of scholars are interpreting "culture" in a variety of definitions. Mills (1970) defines it as "one of the strongest words in social science", or "one of the two or three most complicated words in English" (Williams, 1976), or even "notoriously difficult" (Byram, 1989), "an omnibus term" (Kaplan and Manners, 1972), "all-inclusive" (Saltzman, 1993), while Fay (2008) notes that "it is everything that is shared by a particular group of people". Moreover, culture can be understood as facets of ideas, behaviours and products, such as literature, gestures, food, values, art, religion,

music, language, institutions, customs and traditions and habits. However, there is an ample number of non-visible and subjective dimensions of culture, such as the style one adopts in communication or how one handles conflict. Additionally, De Melendez (2012) mentions that culture can be defined as “a collection of beliefs, attitudes, habits, values, and practices that a human group uses to form a view of reality”. Based on the literature production it is evident that the determination of intercultural education accommodates a majority of concepts which may have an extended and non-specific, but rather general and multifaceted meanings (Kyriakopoulos, 2016a; Kyriakopoulos, 2016b; Kyriakopoulos et al., 2020; Ntanos et al., 2020). On the above basis it is noticeable that culture is a problematic term that entails certain meanings and it connotes different additional meanings, thus, it does not carry an widely agreed definition among scholars (Kroeber & Kluckholm, 1952; Bock, 1999; Deal & Kennedy, 1982; Crane, 1994; Melville & Readings, 1995). In the same vein, culture is certainly related to its features, some of which can be included in the concepts of identity, language, and communication. The latter terms are “inheriting” to culture with an extra burden as “within us we have contradictory identities pulling in different directions, so that our identifications are continuously being shifted about” (Hall, 2006), thus variation in cultural identification is normally acceptable.

Based on the above analysis it is evident that “culture” is an amalgam of notions and concepts; hence it cannot be restricted to a single and universally agreed definition. In the case of “intercultural” the emphasis should inclined move to “inter” since this term implies “interactive relations with others” and “self-in-the-other” and “other-in-the-self” (Gallagher, 2011). In this respect the “intercultural education” is not overemphasized on culture as a set of ideas, behaviours and products which confines people in the boundaries of certain cognitive areas, thus “confirm racist assumptions” of the superiority of the self over the other, but rather postulate citizens of the world to interact and consider the self as part of the other and vice versa (Andreotti, 2011; Hajisoteriou, 2012; Banks and McGee Banks, 2009). Such an investigation of “intercultural education” it is anticipated to play a determining role to the “organizational culture” at almost all operational and managerial fields of operational research and management science among Balkan countries. This research orientation is especially important while considering: a) the versatile ethnic and socio-cultural background of the national workforce among all South-Eastern European countries, as the result of the deep geo-political transitions experienced and b) this workforce is employed in the main sectors of the economy: primary (agriculture, mining), secondary (manufacturing), tertiary (services, retail).

Intercultural Education in Europe

The EU is traditionally responded positively on the issues of intercultural education. EU institutions such as the European Commission, European Council, and Council of Ministers and Council of Europe documents, have established and promoted cultural cooperation. Hajisoteriou (2010) mentioned a number of projects that have been launched to combat discrimination and promote diversity. In 1991 history textbooks were reviewed to eliminate prejudice regarding nationality. In 2002 the new curriculum which was related to the religious dimension of intercultural education was introduced to teachers and policy makers, by a project named “The New Challenge of Intercultural Education: religious diversity and dialogue in Europe”. The project was expanded in 2004. Moreover, the declaration of “Intercultural Education in the New European Context” was approved by the 48 ministers of education in 2003 to signify the adaption of appropriate intercultural dimension in educational policies, educational material, curricula and teacher training. In addition, Faas et al. (2014) reviewed policy documents which were devoted by the EU institutions towards the intercultural education. The Council of Europe, for example, proclaimed policies and practices for teaching sociocultural diversity, in 2005, while in 2007 the role of education policies was embedded in the final declaration for a more humane and inclusive Europe (Hajisoteriou and Angelides, 2013; Pinto, 2018).

Intercultural Education in Greece

Greece, as a EU member state, has to undergo some important changes in the economic, social and cultural life that abiding to its accession to the EU. In the field of education, a curriculum reform was attempted between 1980 and 1996 and another between 1996 and 2002. In the former period, 1980-1996, reforms in the educational system in Greece were reported (Dimaras, 1982; Flouris, 1995; Damanakis, 1998) as indifferent, suggesting no actual change in the rubric or the actual educational goals. Certain priority was given to the subjects of language and mathematics because they were considered highly important for the acquisition of necessary knowledge for career preparation. Textbooks were considered a bible, they ought to be in alignment with the curriculum, while teacher-centered education was the medium for teaching. Knowledge was presented in a fragmented form and information of every school subject was separate and not related. Most importantly, textbooks at the time contained ethnocentric views and cultivated them, which led to the reinforcement of superiority of Greekness over the other nationalities. Western European cultures

were belittled and Greek culture was considered unique (Flouris and Ivrintelis, 2000). Europe in the Greek curriculum showed the superiority of Greek civilization, customs, and traditions (Flouris and Ivrintelis, 2001; Palaiologou and Evaggelou, 2015), being further emphasizing on the validity and importance of Greekness over any other ethnicity (Flouris and Ivrintelis, 2002; Zembylas and Iasonos, 2010). In the 1990's certain social and political changes, i.e. the fall of Soviet Union and the political changes in Albania, led to a wave of repatriated from the former Soviet Union and Albanian students attending Greek public schools. The Ministry of National Education and Religious Affairs initiated a number of actions to overcome the difficulties that those students faced as soon as they entered the so far monolingual and ethnocentric Greek public school. In 1996 the Institute for Repatriate and Intercultural Education (I.P.O.D.E) was founded and 26 intercultural education schools were officially established to support students with a non-Greek background. Foreign language teaching introduction in primary education aimed at the well-intended attempts for intercultural aspects in the Greek educational reality, as well as the work of a great number of specialists, i.e. sociologists, psychologists and social workers, who were hired for reception classes and tutoring departments. Nevertheless, regardless how well-intended the aforementioned policies were, most of them remained unfinished as there was no provision for the future. It is indicatively noted that they catered for off-springs, while there was no plan for older students in secondary education, or in remove schools in the mainland and insular Greek provinces. In addition, the whole project was doomed to failure as official documents, reports and regulations mentioned as “foreign” students and explicitly discriminated them as “others” with certain particularities. Hence it could be commented as an approach which suggested assimilation and exclusion from the educational process (Zachos, 2009; Papamichael, 2008; Tsaliki, 2017).

MATERIALS AND METHODS

An electronic questionnaire was used for the collection of the data for this study. The survey period started in January, 2018 and lasted for 3 months. A total of 160 answers were recorded, involving teachers from both primary and secondary education, who are teaching at the public schools of West Attica. The IBM SPSS software was used for the analysis of the data. The questionnaire contained 18 questions. Most of them were closed questions and there were also four open-ended questions.

RESULTS AND DISCUSSION

The reliability statistics factor Cronbach’s alpha was found to be higher than 0,7, as it can be seen from the chart below. Given the fact that the variables in the investigation are classificatory, the use of the spearman factor was justified to be able to affirm any correlations among the variables that show significance regarding the stance of educators towards intercultural practices.

Table 1 Reliability Statistics

Cronbach's Alpha	N of Items
,793	10

The majority of the educators, (62,5%), claim that they are aware of the basic principles of intercultural education, which have been acquainted either by personal exposure to some form of occupation such as reception classes, or by attending some forms of training such as seminars, or by personal engagement in reading about it. Nevertheless, a considerable number, (35,5%), declare lack of knowledge of the basic principles of intercultural education, due to lack of relevant in-service educational programmes.

The most fundamental question regards frequency of application of intercultural practices in the classroom. On a scale of 0 to 5, that is from never to quite often, 40% have selected often, while only 12,5 % have answered that they never use intercultural practices in their classrooms. It is to be noted however, that 15% responded quite positively in the application of intercultural practices, while another 2 %, affirm that only sometimes apply intercultural practices.

Another question, attempts to investigate the trait that hinders applicability of interculturality in the Greek public school. Only 5% respectively, maintain that parents and negative attitude on the part of teachers hinder them from being able to apply intercultural practices in the classrooms, while another 10%, consider a trait that has not been defined in the questionnaire, responsible for not applying them. A large percentage, (45%) attribute great responsibility to lack of knowledge about the subject of interculturality to their incapability of applying it. The curricula are also considered an important factor for hindering application of intercultural practices (35%). More than half of respondents (60%) observed that there should be changes in the curricula and the educational material should be adapted and revised. The last question of research revealed who might be benefited by the application of intercultural practices. The 50% of respondents indicated students, teachers, parents and the whole educational community as those who would

be mostly benefited, while another 45% responded positively to the whole educational community. Finally, only 5 % considered students among those who would mostly be benefited by the use of intercultural practices in the classrooms.

SUMMARY AND CONCLUDING REMARKS

The study revealed the necessity for educational programmes to inform educators in Greece about intercultural practices, being more confident in applying them, and be familiarize to a broader context of innovations, enabling the teaching autonomy in the classroom regarding the application of such practices (Kyriakopoulos, 2016a; Kyriakopoulos, 2016b). Besides, raising intercultural awareness and acquiring intercultural competence is proven the ultimate goal for a more inclusive public school. These research findings denoted the adoption of intercultural practices in the classrooms as long as the educational community in Greece is experiencing rapid socio-economic evolutions. On the other hand, public school teachers in Greece argue that they feel neither confident with intercultural practices nor willing to regularly apply them, although a quite a large number of respondents claimed that they are aware of them.

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Project Evaluation Criteria Prioritization by Using a Type-2 Fuzzy MCDM Model

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Abstract

Projects have become one of the most important routes to generating business values; so, their success is increasingly becoming an imperative for companies, especially the issue of their evaluation. In that context, it is critical to establish a system of multiple criteria for the evaluation project relevance to an organization's objectives, the probability of its success, its potential performance, the strategic leverage potential or its compliance with available resources. The criteria prioritization, aimed at reflecting organization's preferences with regard to their relative importance is imposed as the major part of evaluation process. However, the key issues accompanying criteria prioritization are: the lot of uncertainties, the impossibility of expressing preferences relations by means of crisp measures, the vagueness of human perception and a lack of quantitative measures. The model proposed in this paper is aimed at responding to those challenges. This model is based on the extending of the Analytic Hierarchy Process for handling fuzzy problems of prioritizing project evaluation criteria within the context of interval type-2 fuzzy sets. Since type-2 fuzzy sets are defined by the intervalvalued membership function which is fuzzy itself, it is able to model different sources of uncertainties and vagueness in the prioritization process, and also to handle the unsuitability issues of type-1 fuzzy sets.

KEYWORDS:

Project evaluation criteria, MCDM, AHP, interval type-2 fuzzy sets

INTRODUCTION

According to Meredith et al. (2017), project management as a business concept has emerged as a response to the characteristics of contemporary society's demand for the development of new management methods. During the last decades, projects have become one of the most important business models and paths to generating business benefits for organizations (Barghoth et al., 2020). As Meredith et al. (2017) point out, projects were spawned by the forces such as the evolution of the worldwide competitive markets for the production and consumption of goods and services, growing demand for a wide range of complex, sophisticated and customized goods and services, and the exponential expansion of human knowledge.

Nevertheless, one of the key issues of the project management process is still the insufficient and incomplete evaluation of a project success and its individual results in order to provide purposeful information for guiding an ongoing project or learning lessons for future projects. Project evaluation involves an assessment employing specific evaluation criteria and measures against standards or the expected values relative to goals or effects relative to strategic plans (Samset & Christensen, 2017). An effective goal-oriented project evaluation necessitates incorporating various conflicting criteria into a decision model; hence, it might be considered as an MCDM problem, which is confirmed by numerous studies (Sadi-Nezhad, 2017; Abdel-Basset et al., 2019; Ma et al., 2020; Pramanik et al., 2020).

Even though the multiple objectives evaluation may provide the optimal solution, its major issue is which priorities should be assigned evaluation criteria. However, the key issues accompanying the criteria prioritization process are a large number of uncertainties, the impossibility of expressing preference relations by means of crisp measures, vagueness of human perception and a lack of quantitative criteria.

This paper is aimed at establishing a model leading to the formation of a systematic concept for the holistic project evaluation based on a set of different indicators, and combination of qualitative and quantitative evaluation criteria. The main focus of the model will be on the framework for a rational and reliable criteria prioritization under a fuzzy environment. The research methodology in the paper includes the following aspects: the identification of the critical project performance indices in order to develop a system of project evaluation criteria; making of proposal for a MCDM model for prioritization of the project evaluation criteria based upon an interval type-2 fuzzy set; and applying the proposed model for the prioritization of identified criteria, with the result analysis.

INTERVAL TYPE-2 SET AND MCDM

Various MCDM-based approaches within the context of interval type-2 fuzzy sets have been emphasized by many studies aimed at reducing uncertainty in decision-making (DM) assessments due to their accuracy in uncertainty modeling. Mohamadghasemi et al. (2020) introduced the integrated FWA-ELECTRE III approach based on interval type-2 fuzzy sets for solving the material handling equipment selection problem. In the study (Ghorabae et al., 2017), the basic concepts of interval type-2 fuzzy sets and the arithmetic operations of trapezoidal interval type-2 fuzzy numbers are used to develop the extended EDAS (Evaluation Based on Distance from Average Solution) method in order to solve a multi-criteria subcontractor evaluation problem. Çolak & Kaya (2017) suggested a fuzzy integrated MCDM model which combines the AHP based on interval type-2 fuzzy sets and the hesitant fuzzy TOPSIS, aimed at prioritizing renewable energy alternatives. The same model was used for DM problems in maritime transportation engineering (Celik & Akyuz, 2018), and for the selection of optimal maintenance strategy under (Mathew et al., 2020).

Fuzzy set theory was introduced by Zadeh (1965). The theory is oriented towards the conversion of human perceptions given as linguistic statements into an arithmetical form by representing the vague data using fuzzy numbers (Zadeh, 1965). Type-1 fuzzy numbers are most often used to describe fuzzy events. The membership function characterizing each type-1 fuzzy number is defined as in (2) and enables the mapping of linguistic statements to a closed interval [0,1]. However, according to Mendel & John (2002), type-1 fuzzy sets are incapable of directly modeling the uncertainties that characterize fuzzy set systems, due to their two-dimensional membership function, which is absolutely crisp.

$$\mu_A(x) = \begin{cases} \frac{x-l}{m-l}, & x \in [l, m], \\ \frac{x-u}{m-u}, & x \in [m, u], \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

On the other hand, the type-2 fuzzy set is more useful for minimizing the impact of uncertainties as well, due to the membership function which is fuzzy in itself. As Mendel & John (2002) indicate, the main source of those uncertainties includes: a) meanings of the used linguistic terms and the consequences of the rules can be uncertain – different people perceive the meaning of these words in different ways; b) consequents may have a histogram of values associated with them, especially when knowledge is extracted from a group of experts who do not have a unified attitude; (c) measurements that activate a type-1 fuzzy logic may be uncertain; (d) data used to tune the parameters of a type-1 fuzzy logic system may also be noisy.

Type-2 fuzzy sets are defined by an interval-valued, three-dimensional membership function, which makes it more competent for modeling those uncertainties, since it is described by both the primary and the secondary memberships to provide more degrees of flexibility. The three-dimensional membership function which characterizes each interval type-2 fuzzy number is defined as in (2), and can also be defined as in (3).

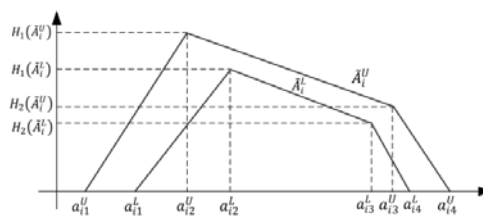
$$\tilde{A} = \{(x, u), \mu_{\tilde{A}}(x, u) \mid \forall x \in X, \forall u \in J_x \subseteq [0,1], 0 \leq \mu_{\tilde{A}}(x, u) \leq 1\} \quad (2)$$

$$\tilde{A} = \int_{x \in X} \int_{u \in J_x} \frac{\mu_{\tilde{A}}(x, u)}{(x, u)} \quad (3)$$

Assume that each $\mu_{\tilde{A}}(x, u)$ is equal to 1; then, \tilde{A} might be presented as in (4), which is graphically presented in the Figure 1.

$$\tilde{A} = (\tilde{A}_i^U, \tilde{A}_i^L) = (a_{i1}^U, a_{i2}^U, a_{i3}^U, a_{i4}^U; H_1(A_i^U), H_2(A_i^U)) (a_{i1}^L, a_{i2}^L, a_{i3}^L, a_{i4}^L; H_1(A_i^L), H_2(A_i^L)) \quad (4)$$

Figure 1 Interval type-2 fuzzy number



Interval type-2 fuzzy AHP

The first step of the prioritization process based upon interval type-2 fuzzy AHP implies the structuring of a DM problem into a hierarchy, including the goal, the criteria and the sub-criteria. Analogous to the established hierarchy of the DM problem, a pairwise comparison matrix ($\tilde{A} = \{\tilde{a}_{ij}\}_{n \times n}$) is constructed (5).

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \dots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \dots & 1 \end{bmatrix} \quad (5)$$

The elements of the pairwise comparison matrix (\tilde{a}_{ij}) represent the preference of the criterion i over the criterion j , specified on the basis of the judgments of the experts involved in the prioritization process. These preferential relations are, first, expressed in a linguistic form (e.g. Absolutely Strong, Very Strong, Fairly Strong, Slightly Strong and Exactly Equal), then converted to a type-2 fuzzy interval (according to the scale given in Table 1) in order to successfully cope with the ambiguity of an experts' judgments.

Table 1 The interval type-2 fuzzy scale

Linguistic Variables	Interval Type-2 Fuzzy Numbers
Absolutely Strong (AS)	(7, 8, 9, 9; 1, 1) (7.2, 8.2, 8.8, 9; 0.8, 0.8)
Very Strong (VS)	(5, 6, 8, 9; 1, 1) (5.2, 6.2, 7.8, 8.8; 0.8, 0.8)
Fairly Strong (FS)	(3, 4, 6, 7; 1, 1) (3.2, 4.2, 5.8, 6.8; 0.8, 0.8)
Slightly Strong (SS)	(1, 2, 4, 5; 1, 1) (1.2, 2.2, 3.8, 4.8; 0.8, 0.8)
Exactly Equal (EE)	(1, 1, 1, 1; 1, 1) (1, 1, 1, 1; 1, 1)

The matrix (\tilde{A}) is reciprocal, thus:

$$\tilde{a}_{ij} = \frac{1}{\tilde{a}_{ji}} \quad (6)$$

As \tilde{a}_{ij} is given in the form of interval type-2 fuzzy numbers (7) then:

$$\tilde{a}_{ij} = (a_{11}^U, a_{12}^U, a_{13}^U, a_{14}^U; H_1(a^U), H_2(a^U))(a_{11}^L, a_{12}^L, a_{13}^L, a_{14}^L; H_1(a^L), H_2(a^L)) \quad (7)$$

$$\frac{1}{\tilde{a}_{ij}} = \left(\frac{1}{a_{14}^U}; \frac{1}{a_{13}^U}; \frac{1}{a_{12}^U}; \frac{1}{a_{11}^U}; H_1(a^U), H_2(a^U) \right) \left(\frac{1}{a_{14}^L}; \frac{1}{a_{13}^L}; \frac{1}{a_{12}^L}; \frac{1}{a_{11}^L}; H_1(a^L), H_2(a^L) \right) \quad (8)$$

If the DM process includes n experts, individual fuzzy comparison matrices could be aggregate by means of the fuzzy geometric mean method (9), where \tilde{a}_{ij}^k is the assessment given by the k^{th} expert.

$$\hat{a}_{ij} = (\prod_{i=1}^n \tilde{a}_{ij}^k)^{\frac{1}{n}} = [\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \dots \otimes \tilde{a}_{ij}^n]^{\frac{1}{n}} \quad (9)$$

$$\sqrt[n]{\hat{a}_{ij}} = \left(\sqrt[n]{a_{ij1}^U}, \sqrt[n]{a_{ij2}^U}, \sqrt[n]{a_{ij3}^U}, \sqrt[n]{a_{ij4}^U}; H_1^U(a_{ij}); H_2^U(a_{ij}) \right) \left(\sqrt[n]{a_{ij1}^L}, \sqrt[n]{a_{ij2}^L}, \sqrt[n]{a_{ij3}^L}, \sqrt[n]{a_{ij4}^L}; H_1^L(a_{ij}); H_2^L(a_{ij}) \right) \quad (10)$$

The fuzzy weight of the i^{th} criterion first requires the calculation of the fuzzy geometric mean (\hat{r}_i) as in (11).

$$\hat{r}_i = (\prod_{i=1}^n \hat{a}_{ij})^{\frac{1}{n}} = [\hat{a}_{i1} \otimes \hat{a}_{i2} \otimes \dots \otimes \hat{a}_{in}]^{\frac{1}{n}} \quad (11)$$

Then, the interval type-2 fuzzy criteria weight (w_i) is obtained by (12).

$$w_i = \hat{r}_i \otimes [\hat{r}_1 \oplus \dots \oplus \hat{r}_n]^{-1} \quad (12)$$

The final step implies the defuzzification of the obtained interval type-2 fuzzy criteria weight w_i by means of the geometric mean method as in (13), where w_j represents the arithmetical mean of the upper bound and the lower bound to the interval type-2 fuzzy weights.

$$\tilde{w}_j = \frac{\int xu(x)dx}{\int u(x)dx} = \frac{-w_{j1} \cdot w_{j2} + w_{j3} \cdot w_{j4} + \frac{1}{3}(w_{j4} - w_{j3})^2 - \frac{1}{3}(w_{j2} - w_{j1})^2}{-w_{j1} - w_{j2} + w_{j3} + w_{j4}} \quad (13)$$

PROJECT EVALUATION CRITERIA PRIORITIZATION

The establishment of the project evaluation criteria system – Project evaluation necessitates incorporating both the aspect of a project success, which deals with the project final outcome, such as the impact caused by the project, financial performance, quality etc., and the aspect of a project management success, focused upon the efficiency of the project process, the project feasibility and so on. As highlighted in (OECD, 2002), the major evaluation aspects should be project 1) relevance, 2) efficiency, 3) effectiveness, 4) impacts and 5) sustainability. For achieving a comprehensive approach to evaluation of project success it is necessary to establish project evaluation criteria system which includes tangible and intangible criteria, covering the main aspects of project success, derived from the project objectives.

Taking into account the project general objectives the key project evaluation criteria have been identified: **C₁ Net present value** – as a dynamic project evaluation criterion, it is an indicator of project investment profitability, and it refers to the value of all positive and negative future cash flows over the entire life of a project investment; **C₂ Payback period** – as a measure of the project investments efficiency it shows length of time an investment reaches a break-even point; **C₃ Project cycle time** – as an indicator of efficiency in project implementation, it includes overall time necessary for transformation of project inputs into planed outputs, or the time from the project launch to its closure; **C₄ Project**

feasibility – consider the level of the project risks and the alignments of the existing organizational experience, the managers’ and company staff’s competences and capabilities, the availability of materials, the machinery and other work essentials, with the project requirements or the complexity level; **C₅ Project impact** – encompassing the project impacts on customer satisfaction, cost reduction, generation of a company profit, upgrading the quality, operational performance upgrading, improvement of the competition capability or interaction of the project cash flow with the existing projects; and **C₆ Project sustainability** – includes considering of financial, economic and social aspects of project sustainability.

The construction of an interval type-2 fuzzy pairwise comparison matrix – According to the experts’ attitudes (the prioritization process involved a total of three experts from the key project knowledge areas) towards the importance of the considered project evaluation criteria, the pairwise comparison matrices were formed by using the linguistic variables (Table 2), which were further converted into interval type-2 fuzzy numbers, according to the scale given in Table 1.

Table 2 The linguistic evaluations matrices

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆
C ₁	EE,EE,EE	VS,SS,FS	FS,VS,SS	EE,SS,EE	EE,SS,EE	SS,FS,1/SS
C ₂	1/VS,1/SS,1/FS	EE,EE,EE	1/SS,1/FS,SS	1/FS,1/VS,1/VS	1/AS,1/AS,1/VS	1/SS,1/FS,EE
C ₃	1/FS,1/VS,1/SS	SS,FS,1/SS	EE,EE,EE	1/SS,1/FS,SS	1/VS,1/AS,1/FS	EE,SS,1/SS
C ₄	EE,1/SS,EE	FS,VS	SS,FS,VS,1/SS	EE,EE,EE	1/SS,1/FS,1/SS	SS,EE,EE
C ₅	EE,1/SS,EE	AS,AS,VS	VS,AS,FS	SS,FS,SS	EE,EE,EE	FS,VS,FS
C ₆	1/SS,1/FS,SS	SS,FS,EE	EE,1/SS,SS	1/SS,EE,EE	1/FS,1/VS,1/FS	EE,EE,EE

As the result of the consolidation of the experts’ individual evaluations by means of the geometrical mean method (9), the aggregation matrix was obtained (Table 3).

Table 3 The aggregated interval type-2 fuzzy comparison matrix for the relative importance of the criteria

	C ₁	C ₂	C ₃	C ₄	C ₅	C ₆
C ₁	(1,1,1,1;1,1) (1,1,1,1;1,1) (0.12,0.13,0.17,0.21;1,1)	(4.72,5.77,7.56,8.28;1,1) (4.93,5.98,7.36,8.14;0.8,0.8)	(2.47,3.63,5.77,6.80;1,1) (2.71,3.85,5.56,6.6;0.8,0.8)	(1.1,26,1.59,1.71;1,1) (1.06,1.3,1.56,1.69;0.8,0.8)	(0.52,0.69,1.1,1.19;1,1) (0.56,0.72,0.97,1.14;0.8,0.8)	(0.84,1.26,2.29,3.27;1,1) (0.93,1.34,2.16,3.01;0.8,0.8)
C ₂	(0.12,0.14,0.17,0.20;0.8,0.8) (0.15,0.17,0.28,0.41;1,1)	(1,1,1,1;1,1) (0.84,1.26,2.29,3.27;1,1)	(0.33,0.46,0.74,1.08;0.8,0.8) (1,1,1,1;1,1)	(0.12,0.14,0.18,0.23;0.8,0.8) (0.31,0.44,0.79,1.19;1,1)	(0.11,0.12,0.13,0.15;0.8,0.8) (0.12,0.13,0.17,0.21;1,1)	(0.31,0.36,0.48,0.64;0.8,0.8) (0.58,0.79,1.26,1.71;1,1)
C ₃	(0.15,0.18,0.26,0.37;0.8,0.8) (0.58,0.63,0.79,1,1,1)	(0.93,1.34,2.16,3.01;0.8,0.8) (4.22,5.24,7.27,8.28;1,1)	(1,1,1,1;1,1) (0.84,1.26,2.29,3.27;1,1)	(0.33,0.46,0.74,1.08;0.8,0.8) (1,1,1,1;1,1)	(0.12,0.14,0.17,0.20;0.8,0.8) (0.18,0.22,0.4,0.69;1,1)	(0.63,0.83,1.2,1.59;0.8,0.8) (1,1,26,1.59,1.71;1,1)
C ₄	(0.59,0.64,0.77,0.94;0.8,0.8) (0.58,0.63,0.79,1,1,1)	(4.42,5.45,7.07,8.08;0.8,0.8) (6.26,7.27,8.65,9,1,1)	(0.93,1.34,2.16,3.01;0.8,0.8) (4.72,5.77,7.56,8.28;1,1)	(1,1,1,1;1,1) (1.44,2.52,4.58,5.59;1,1)	(0.19,0.23,0.37,0.6;0.8,0.8) (1,1,1,1;1,1)	(1.06,1.3,1.56,1.69;0.8,0.8) (3.56,4.58,6.6,7.61;1,1)
C ₅	(0.59,0.64,0.77,0.94;0.8,0.8) (0.31,0.44,0.79,1.19;1,1)	(6.46,7.47,8.45,8.93;0.8,0.8) (0.58,0.79,1.26,1.71;1,1)	(4.93,5.98,7.36,8.14;0.8,0.8) (0.58,0.79,1.26,1.71;1,1)	(1.66,2.73,4.38,5.39;0.8,0.8) (0.58,0.63,0.79,1,1,1)	(1,1,1,1;1,1) (0.13,0.15,0.22,0.28;1,1)	(3.76,4.78,6.4,7.41;0.8,0.8) (1,1,1,1;1,1)
C ₆	(0.33,0.46,0.74,1.08;0.8,0.8)	(0.63,0.83,1.2,1.59;0.8,0.8)	(0.63,0.83,1.2,1.59;0.8,0.8)	(0.59,0.64,0.77,0.94;0.8,0.8)	(0.13,0.16,0.21,0.27;0.8,0.8)	(1,1,1,1;1,1)

The calculation of the interval type-2 fuzzy criteria weights and their defuzzification – The fuzzy geometric mean of each criterion was calculated by using Eq. (11), as shown in Table 4.

Table 4 The criteria fuzzy geometric means

	Interval type-2 fuzzy criteria geometric means (\hat{r}_i)	
C ₁	(1.313,1.687,2.326,2.684;1,1)	(1.396,1.755,2.260,2.604;0.8,0.8)
C ₂	(0.231,0.261,0.349,0.433;1,1)	(0.237,0.269,0.337,0.412;0.8,0.8)
C ₃	(0.373,0.464,0.691,0.911;1,1)	(0.392,0.483,0.661,0.853;0.8,0.8)
C ₄	(0.848,1.023,1.423,1.783;1,1)	(0.885,1.057,1.373,1.688;0.8,0.8)
C ₅	(2.111,2.594,3.409,3.833;1,1)	(2.215,2.684,3.32,3.739;0.8,0.8)
C ₆	(0.448,0.545,0.776,0.996;1,1)	(0.468,0.564,0.746,0.938;0.8,0.8)

Table 5 The criteria weights

	Interval type-2 fuzzy criteria weight	Defuzzified weights (w_i)	Normalized weights (\tilde{w}_j)
C ₁	(0.113,0.173,0.331,0.479;1,1)	(0.125,0.186,0.31,0.441;0.8,0.8)	0.275
C ₂	(0.02,0.027,0.05,0.077;1,1)	(0.021,0.028,0.046,0.07;0.8,0.8)	0.043
C ₃	(0.032,0.048,0.098,0.162;1,1)	(0.035,0.051,0.091,0.144;0.8,0.8)	0.084
C ₄	(0.073,0.105,0.203,0.318;1,1)	(0.079,0.112,0.188,0.286;0.8,0.8)	0.173
C ₅	(0.181,0.266,0.485,0.684;1,1)	(0.198,0.284,0.455,0.633;0.8,0.8)	0.402
C ₆	(0.038,0.056,0.11,0.178;1,1)	(0.042,0.06,0.102,0.159;0.8,0.8)	0.095

Based on the obtained fuzzy geometric means, the interval type-2 fuzzy weights were finally calculated according to Eq. (12). These weights were defuzzified by Eq. (13) and then normalized (Table 5). Considering the assessments given by

the experts engaged in the conducted prioritization process, the most important aspect of project evaluation is Project impact, followed by Net present value and Project feasibility.

CONCLUSIONS

The paper contributes to the formulation of a systematic holistic project evaluation concept based on a set of different indicators, and a combination of qualitative and quantitative evaluation criteria, taking into account the two aspects, namely a project success, which deals with the project final outcome, and the project management success, focused on project process. The main paper contribution implies revealing a reliable approach aimed at reflecting an organization's preferences for the relative importance of evaluation criteria and the priority of the set objectives. Also, the proposed MCDM criterion prioritization model based upon the extension of the AHP within the context of the interval type-2 fuzzy set allowed our successful dealing with key challenges of the process, including a lot of uncertainties, impossibility of expressing preference relations by means of crisp measures, vagueness of human perception.

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Session 13:
Multiple Criteria Decision Analysis
chair: Michael Madas

Assessing Level of Service in Airport Terminals: a MUSA Approach

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Abstract

Level of Service Quality (LoSQ) constitutes a key element and performance metric in airport terminals. The LoSQ of an airport is considered to be of primary importance for the attractiveness, operational and economic viability of contemporary airports around the world. The rapidly increasing air travelling public and the associated impacts on passenger service quality have stimulated an increasing attention from both practitioners and researchers in the broader airport community. Service quality and passenger satisfaction analysis have been the subject of numerous research studies, some with special emphasis placed on airport terminals from the perspective of passengers. How service quality is perceived by passengers is subjective to a large extent, since it is a cognitive process incorporating individual experiences and expectations. In addition, it is context-dependent and can be affected by a large variety of factors or service quality attributes. In our paper, we first conduct a Systematic Literature Review (SLR) to identify, critically assess and synthesize the critical passenger satisfaction and service quality dimensions in the context of airport terminals. Then, we propose a multi-criteria assessment framework, consisted of 8 passenger satisfaction criteria and 53 sub-criteria, based on the Multi-criteria Satisfaction Analysis (MUSA) methodology. The proposed assessment framework is demonstrated for Thessaloniki Airport "Makedonia" in Greece. For the purposes of our analysis, 367 structured survey instruments were collected through both physical, on-site interviews and an online questionnaire. Overall, the results revealed non demanding passengers, with a good level of satisfaction. The ranking of criteria in descending order of satisfaction are safety/security, staff, information, comfort, services, mobility and accessibility, facilities and shops/restaurants. The main areas of improvement were indicated for restaurants in terms of prices, facilities with regard to availability and cleanliness, the effectiveness of the baggage claim processes and immigration checks, as well as comfort in waiting and gate areas.

KEYWORDS

Service quality, passenger satisfaction, airport terminal, multi-criteria analysis, MUSA

INTRODUCTION

In the modern world and economies, the Level of Service Quality (LoSQ) of an airport is encountered to be of primary importance for the attractiveness and, consequently, for the business of an airport (Bellizzi et al., 2018; Pantouvakis & Renzi, 2016). The increasing travelling traffic in air transportation has directed the management of the airports to measure, analyze and interpret the opinions of the passengers, which reflect their perceptions with regard to Airport Service Quality (ASQ) (Bezerra & Gomes, 2015). The measurement of the service quality, as well as the passenger satisfaction that can reflect the level of quality is a complex process, since it depends on a large numbers of variables, some of which may be directly observable, but many are not straightforward indicators and cannot be observed directly. Within the existing literature, the study approaches for measuring passenger satisfaction and service quality differ, both in terms of the methodology applied and in terms of quality criteria used and their classification.

Numerous research efforts have been conducted with view to assessing the quality of services in an airport terminal, mainly viewed under the perspective of passenger satisfaction (De Barros et al., 2007; Fodness and Murray, 2007; Yau and Tang, 2018). It has been found that there are a lot of different activities and states in an airport that may contribute to the level of the service and may influence passenger satisfaction. There are different ways to categorize these attributes. In our paper, we aim to synthesize and categorize the various passenger satisfaction dimensions in airport terminals through a Systematic Literature Review (SLR) approach. Subsequently, and most importantly, we develop and demonstrate a multi-criteria assessment model aiming to measure passenger satisfaction from services provided in Thessaloniki Airport "Makedonia", based on the Multi-criteria Satisfaction Analysis (MUSA) methodology.

SYSTEMATIC LITERATURE REVIEW

The research scope of this work lies on the intersection of customer satisfaction, airport services and service quality. Search strings and related keywords used within the framework of the Systematic Literature Review (SLR) process involve the following:

- String 1: “passenger satisfaction” or “customer satisfaction” or “service quality” or “quality of service” or “level of service”
- String 2: “airport terminal” or “airport passenger terminal” or “airport performance”
- String 3: “MuSA” or “MuSA method” or “multi criteria satisfaction analysis” or “multi criteria” or “assessment”

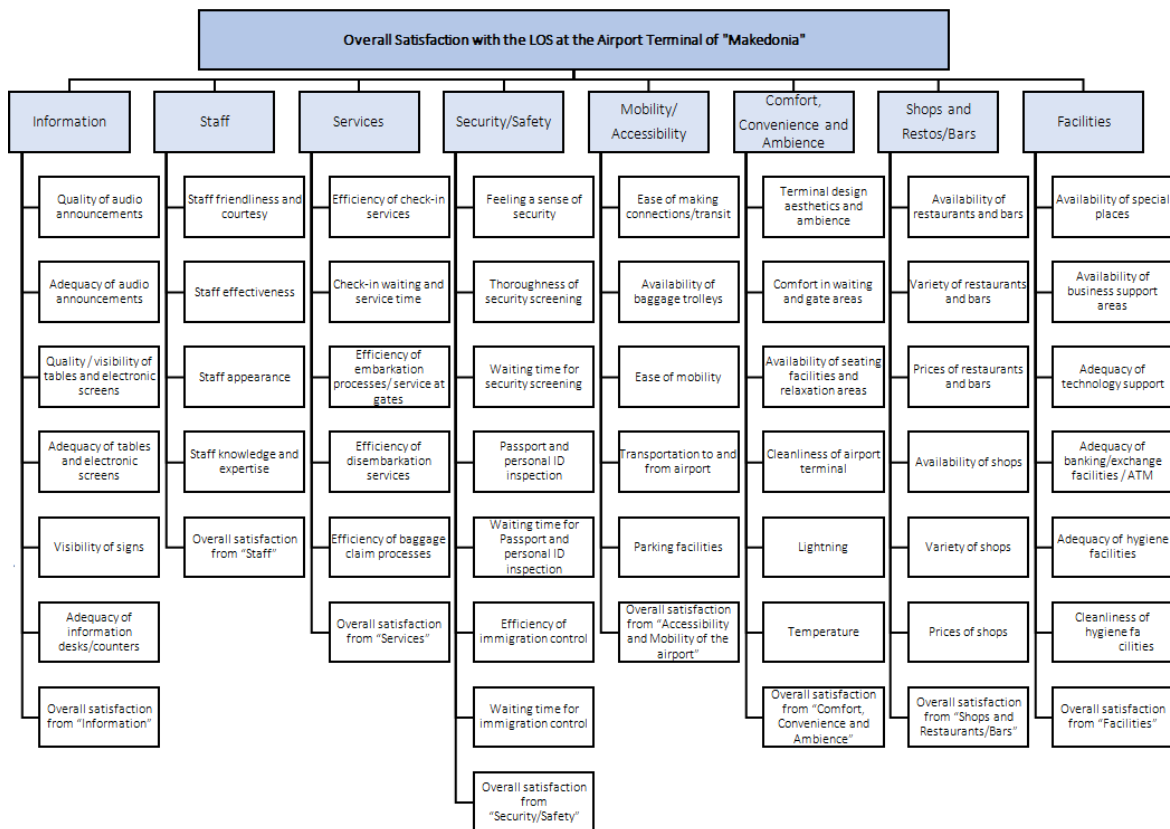
The academic databases and search engines searched for the purposes of the present study were Scopus, WebOfScience, ProQuest Central and Google Scholar. A total of 276 articles were originally found after the application of the exclusion and inclusion criteria. Following a second-round screening and relevance assessment process, we ended up with a core list of relevant literature including 53 articles. As far as the research methods are concerned, the majority of the articles were based on quantitative research. Structured Equation Modeling (SEM) was frequently used as a powerful tool to analyze complex relationships between factors that may affect satisfaction. Indicatively, Bezerra and Gomes (2016) developed a SEM to analyze the relationship between service quality dimensions and passenger characteristics. Another popular analysis approach was based on fuzzy multi-criteria decision making (Pandey, 2016). Logistic regression was applied by Mattozo et al. (2012) to measure airport customer satisfaction. Yeh et al. (2011) and Kuo and Liang (2011) used the fuzzy multi-attribute decision making approach to evaluate airport performance. The thematic analysis revealed also the main drivers of customer satisfaction and service quality assessment for airport terminals. Eboli and Mazzulla (2009) highlighted personnel competence, helpfulness and appearance, while other researchers (Rocha et al., 2016; Lupo, 2015; Bezerra and Gomes, 2015) reported safety and security, check-in services, waiting time, ambience, facilities and staff, and prices as important determinants of passenger satisfaction.

METHODOLOGY

MuSA is a method based on a multi-criteria analytical - synthetic approach designed for customer satisfaction measurement and analysis. MuSA method aims to make a synthesis of the judgments of the individual users/clients to a total satisfaction function, considering that the overall client satisfaction depends on a set of variables (criteria) representing the characteristics of the service (Grigoroudis and Siskos, 2002). A multicriteria analysis using MUSA method is based on quantitative data and the analysis of criteria and sub-criteria, along with their weights, in order to obtain an overall assessment of the passenger satisfaction and potential areas of improvement.

According to an extensive literature review, our multi-criteria, MUSA-based assessment model for passenger satisfaction in airport terminals is structured into 8 first-level criteria that are further split into satisfaction sub-criteria/indicators (Figure 1). The “Information” criterion accounts for designation signs, audio announcements, screen information and information desks (Bezerra and Gomes, 2015; 2016; Pandey, 2016; De Barros et al., 2007; Wiredja et al., 2019). The satisfaction from the “Staff” attitude and service (e.g., friendliness, courtesy, appearance) represents another criterion (Ao and So, 2018; Bellizzi et al., 2018; Bezerra and Gomes, 2015; 2016; De Barros et al., 2007; Mattozo et al., 2012; Pandey, 2016; Tsafarakis et al., 2018). The “Services” criterion deals with the large variety of services provided to departing and arriving passengers and refers to check-in procedures, disembarking, baggage claim, security screening, passport control, as well as immigration checking (Bezerra and Gomes, 2015; 2016; Bulut et al., 2016; Correia et al., 2008; Fodness and Murray, 2007; Tsafarakis et al., 2018). “Security” expresses the sense of security perceived by the passengers (Bezerra and Gomes, 2015; 2016; Pandey, 2016). The “Mobility and Accessibility” criterion contains a group of aspects referring to the satisfaction of the passengers with respect to how they can move to and from the airport, as well as within the airport (e.g., ease of connections/transit, availability of baggage trolleys, transportation to and from airport / ground and parking facilities) (Ao and So, 2018; Bulut et al., 2016; Pandey, 2016; Wiredja et al., 2019). The “Comfort, Convenience and Ambience” criterion accounts for aspects such as the availability of seats, elevators and escalators/moving walkways), as well as the general comfort in waiting and gate areas (Pandey, 2016; Wiredja et al., 2019). The “Shops and F&B” criterion measures the satisfaction derived by shopping outlets and restaurants/bars. Finally, under the criterion of “Facilities”, one can assess satisfaction elements related to sanitary, business and electronic facilities, and other supporting, banking/exchange facilities etc. (Bezerra and Gomes, 2015; 2016; Bulut et al., 2016; Pandey, 2016).

Figure 1: Overall Satisfaction Assessment Model



RESULTS

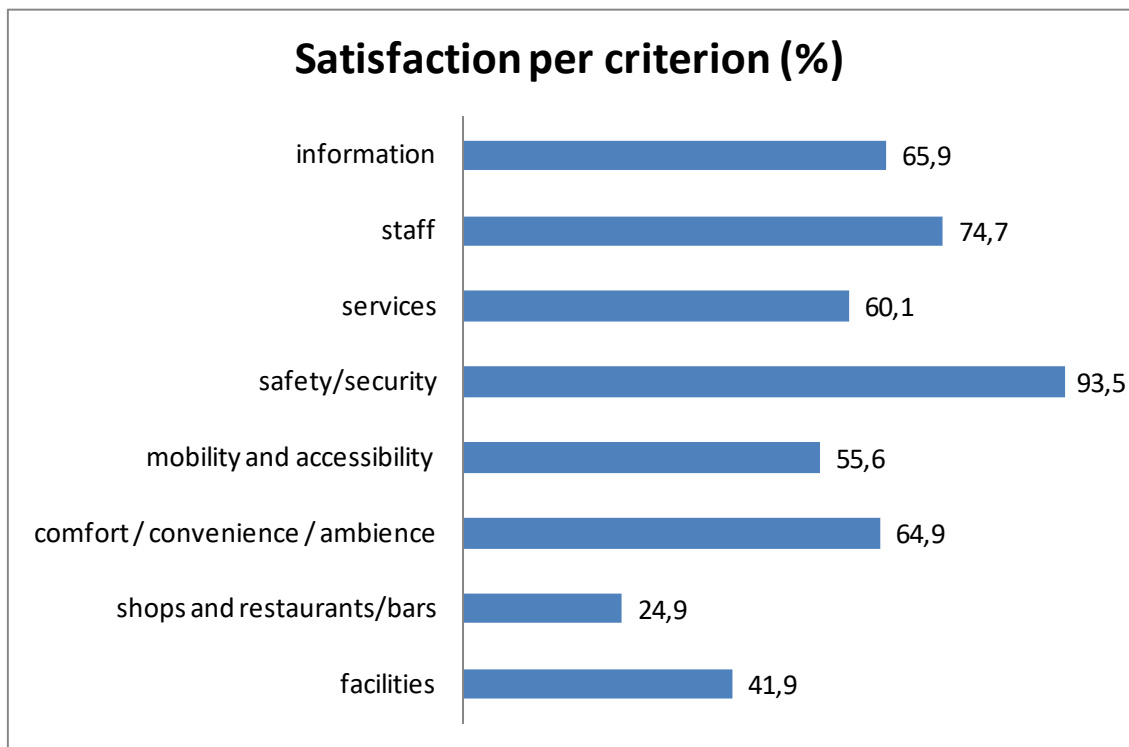
Data collection, both in person and electronic took place in the period between September and October of the year 2019. The sample of the survey consisted of 367 passengers travelled via Thessaloniki (SKG) airport. Table 1 presents the frequencies (percentages) of the level of satisfaction in a 5-point scale (Very Dissatisfied - VD, Dissatisfied - D, Neither dissatisfied Nor Satisfied - NDNS, Satisfied - S and Very Satisfied - VS), for each criterion 1-8 (see Figure 1 above). It can be noticed that the most popular response for almost all criteria is NDNS, with the exemption of criterion 2 (staff), for which the dominating reply is "Satisfied" and criterion 4 (safety/security) for which the replies for NDNS and S have the same frequency (37,3%).

Table 1: Satisfaction level frequencies per satisfaction criterion

	Global	1	2	3	4	5	6	7	8
Very Dissatisfied	1,36	3,27	2,18	4,09	1,36	6,81	2,73	12,53	8,72
Dissatisfied	21,80	22,62	7,36	19,62	11,17	22,62	16,89	33,52	21,53
Neither Dissatisfied-Nor Satisfied	43,05	38,15	32,70	39,78	37,33	40,33	40,33	38,15	43,87
Satisfied	29,70	30,25	42,51	29,70	37,33	23,71	31,88	13,90	21,80
Very Satisfied	4,09	5,72	15,26	6,81	12,81	6,54	8,17	1,91	4,09
Total	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

The level of satisfaction per criterion as it has been estimated by the MuSA method is presented in Figure 2, demonstrating that the criterion accounting for the highest level of passenger satisfaction is safety/security (93,5%). The measurement of the satisfaction level/index is separately for each criterion, measuring how satisfied are the passengers for the specific aspect of the assessment in a range 0-100. The results show that the second criterion with respect to the satisfaction level is staff (74,7%), third is information (65,9%), fourth is comfort/convenience/ambience (64,9%), then services (60,1%), as well as mobility and accessibility (55,6%). The two criteria exhibiting the lowest satisfaction scores were facilities (41,9%) and shops and restaurants/bars (24,9%), indicating low/moderate passenger satisfaction levels.

Figure 2: Satisfaction index per criterion



CONCLUSIONS

The herewith presented research aimed at assessing the perceived level of passenger satisfaction from the services provided by Thessaloniki (SKG) airport. The analysis of the data collected from 367 SKG passengers highlighted a fairly high satisfaction level with respect to safety and security, staff, information, as well as comfort/convenience/ambience. On the other hand, low/moderate satisfaction levels were observed in infrastructural elements like facilities, shops and restaurants/bars. These essentially signify some potential areas of improvements or future investments that are actually in line with terminal investments currently in progress in SKG airport. Some future research directions might investigate differences in satisfaction perceptions with respect to demographic or nationality (e.g., origination of incoming tourists) attributes, as well as improvement actions and plans that would be able to cope with areas of low passenger satisfaction performance.

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Analysis of Passenger Satisfaction in Greek Railways: A Multicriteria Approach

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Abstract

The ultimate goal of transport operators is to ensure high quality of transport services as a prime determinant of passengers' choices. Passengers having a satisfactory travel experience are more likely to use the transport service again, while this can be also critical for the expansion of the existing clientele. This paper aims to develop and demonstrate a generic multicriteria framework for assessing railway passenger satisfaction, which would help railway operators monitor, control and improve the quality of services provided to the travelling public. The proposed framework is built on the basis of 8 first-level criteria (Safety, Cleanliness, Comfort, Ticket Purchase, Information, Reliability and Flexibility, Personnel and Accessibility) and 32 sub-criteria/indicators. The evaluation process was operationalized by means of the Multicriteria Satisfaction Analysis (MUSA) method. The proposed multi-criteria framework is demonstrated for the case of railway passenger services in Greece. The analysis of the results reveals that Greek railway passengers exhibit a quite low overall satisfaction in the order of 33%. The criterion of "Cleanliness" demonstrates the lowest satisfaction rate (11.94%), while simultaneously having the greatest impact on overall satisfaction.

KEYWORDS

service quality, passenger satisfaction, railway, multicriteria analysis, MUSA.

INTRODUCTION

Measuring customer satisfaction is one of the most important issues for contemporary firms and organizations. The principle of measurement constitutes an essential function of management science in that it lays the ground for understanding, analysis and improvement. The definition of customer satisfaction is, in many cases, intermingled or interchangeably used with other related concepts such as quality, value and customer support pertaining to a product or service. Parasuraman et al. (1988) emphasized that satisfaction is a customer perception, which implies that it is not tangible or immediately available, but extra effort should be made to measure, analyze and interpret. Therefore, customer satisfaction is directly related with the service quality provided. In the transport sector in particular, one of the primary goals of operators is to create a well-organized transport system in which citizens have the opportunity to satisfy their needs for efficient mobility in a safe and comfortable environment (Tyrinopoulos and Aifadopolou, 2008). During the last decade, an increasing interest in measuring passenger satisfaction levels has been noticed, as proven by the growing number of studies conducted on public transportation systems mainly in Europe and Asia (Geetika and Shefali, 2010; Fu et al., 2017; Isikli et al., 2017).

Previous transportation-related research has identified many significant factors and attributes of railway passenger satisfaction. However, the effect of these factors on overall passenger satisfaction has not been sufficiently studied. Furthermore, a multi-criteria approach being capable of providing specific insights into satisfaction criteria-related actions for improvements would merit some further exploration. The aim of this research is to develop and apply a generic multi-criteria framework for assessing passenger satisfaction from the use of rail transport services and developing action plans for service improvements. The assessment framework was built on the basis of MUSA (MULTicriteria Satisfaction Analysis) methodology, a consumer-oriented, multicriteria assessment technique for measuring and analyzing customer satisfaction (Grigoroudis and Siskos, 2002). The herewith presented assessment framework will be applied in the case of railway passenger transportation in Greece. The purpose of this analysis is to determine both the overall level of passenger satisfaction using the rail transportation system and the most impacting service features on overall satisfaction. Furthermore, we attempt to identify the service strengths and weaknesses and identify which quality features require immediate improvement actions.

LITERATURE REVIEW

The literature review has been conducted through the Systematic Literature Review (SLR) methodology (Jesson et al., 2011). The process is initiated with the scoping of our research that lies on the intersection of three dimensions, namely service quality, transport and multi-criteria analysis. In particular, we aim to identify relevant research pertaining to the application of multi-criteria analysis methods for assessing service quality in the transport context. Scopus, ScienceDirect, Business Source Complete (EBSCO) and Google Scholar are selected as the primary data sources for literature search. Keywords used for search purposes split into three strings containing the main themes of our research scope: i) String 1 related to “customer satisfaction” keywords, ii) String 2 pertaining to “railway/transport” and iii) String 3 related to “multicriteria analysis”. Based on our search strategy, a total of 1,636 articles were initially found and then subsequently filtered and scaled down according to inclusion/exclusion criteria to 36 articles retained and selected as the core literature list to be reviewed and further analyzed.

Evaluating service quality and efficiency in rail passenger transport has been the subject of research by many researchers worldwide. Many researchers have applied existing methodologies to measure passenger satisfaction, while others have developed new or adapted existing methodologies for this specific purpose. Nathanail (2007) developed a multi-criteria evaluation framework to help rail operators monitor and control the quality of services provided to their passengers under six criteria (i.e., itinerary accuracy, system safety, cleanness, passenger comfort, servicing and passenger information). Geetika and Shefali (2010) proposed a model to measure passenger satisfaction on Indian railway platforms through factor analysis by using 16 variables, grouped into five categories: refreshments, information system, safety and security, behavioral aspects, and basic facilities. Eboli and Mazzulla (2012) proposed a Structural Equation Modelling (SEM)-based tool for analyzing passengers’ perceptions about satisfaction with a particular application at a railway service in North Italy. The model was based on service quality attributes such as punctuality, regularity and frequency of runs, cleanliness, as well as comfort, information, personnel and safety.

Other researchers incorporated broader perspectives of passenger satisfaction and service quality and adopted both quantitative and qualitative methods in the context of rail transport services. Nedeliaková et al. (2014) proposed new methodics of identification of the level of service quality on rail transport (e.g., accessibility, customer care, time and information). Fu et al. (2017) proposed a multi-level extensible assessment model based on the matter element theory and the extension theory in order to evaluate rail transport quality on the basis of 7 primary assessment indices (i.e., safety, cleanliness, comfort, service reliability and availability, information, personnel, other) and 26 senior assessment indices. Isikli et al. (2017) conducted an analysis of service quality for passengers in Istanbul’s railways using voting procedures to determine the highly-prioritized criteria among waiting time, crowding in vehicles, fare, cleanliness, information systems at stations, attitude of security personnel, access to stations etc.

Another major stream of research has focused on the evaluation of quality of rail transport services through the use of the SERVQUAL method (Parasuraman et al., 1988). SERVQUAL is a multi-dimensional research instrument designed to measure service quality by capturing respondents’ expectations and perceptions. Existing relevant research has revealed that this methodology or its variations thereof tend to constitute the dominant measurement mechanism of service quality in Indian railways (Hundal and Kumar, 2015; Priyadharshini and Selladurai, 2016). Maruvada and Bellamkonda (2010) developed a comprehensive instrument called “RAILQUAL” by integrating SERVQUAL with Fuzzy Set theory in order to evaluate the service quality of the Indian railways.

MULTICRITERIA ANALYSIS

MUSA Methodology

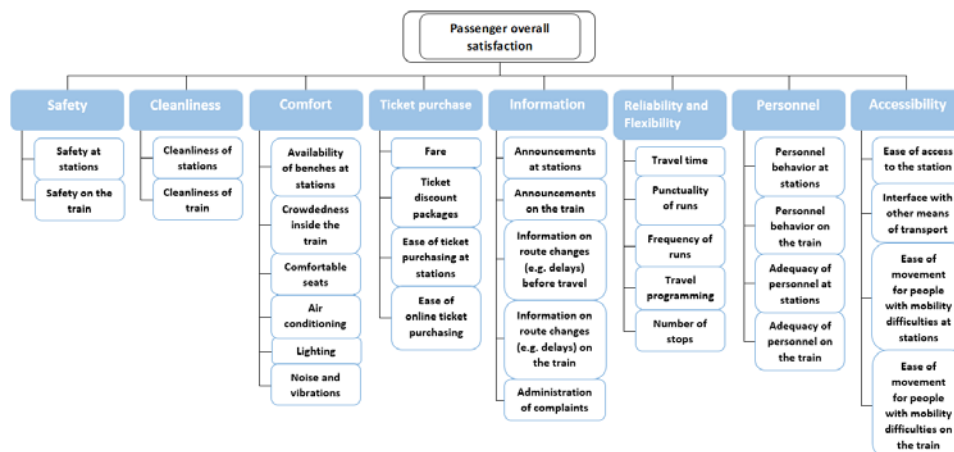
The MUSA methodology constitutes a consumer-based tool for measuring and analyzing customer satisfaction. In our research, the data was analyzed using MUSA methodology in order to address the given assessment problem with view to multiple criteria of passenger satisfaction, since it fully respects the qualitative form of customers' judgments and preferences, as they are expressed in a customer satisfaction survey (Grigoroudis and Siskos, 2002). Furthermore, the obtained results are sufficient to give a clear understanding, and analyze in depth the customer satisfaction in its entirety, including the constituent elements of global customer satisfaction.

The MUSA methodology is a multicriteria preference disaggregation approach, which provides quantitative measures of customer satisfaction considering the qualitative form of customers' judgments. The main objective of MUSA is the aggregation of individual judgments into a collective value function, assuming that the client's global satisfaction depends on a set of n criteria or variables representing service characteristic dimensions (Grigoroudis and Siskos, 2000). The MUSA methodology assesses global and partial satisfaction functions respectively on the basis of given customers' judgments. It should be noted that the method follows the principles of ordinal regression analysis under constraints using linear programming techniques. It provides a large set of outcomes like global satisfaction index, criteria/sub-criteria satisfaction indices, weights of criteria, demanding indices and action and improvement diagrams.

Evaluation Model

Based on an extensive study of the existing literature on the service quality assessment of transport services, a total of eight (8) satisfaction dimensions were defined as the primary, first-level criteria (namely Safety, Cleanliness, Comfort, Ticket purchase, Information, Reliability and Flexibility, Personnel and Accessibility) and 32 second-level sub-criteria/indicators. Figure 1 presents, in detail, the hierarchical structure of railway passenger satisfaction evaluation problem. To survey passenger satisfaction, the determined criteria and sub-criteria have been included in a structured questionnaire that was developed in line with the methodological properties of MUSA methodology.

Figure 1. Hierarchical structure of evaluation model



Results

Data/responses for the present study were collected through simple random sampling between May and June 2019 based on physical presence at Thessaloniki rail station and online form. A number of 312 completed questionnaires were collected and analyzed in total. The results of the overall analysis revealed a very low global satisfaction level for the passengers, with the global satisfaction index pertaining to only 33.01%, indicating that the passengers are quite dissatisfied with the currently provided services in Greek railways. Regarding each service quality criterion separately, as it can be seen in Table 1 below, it is obvious that the Greek railway passengers found almost all of the criteria not satisfactory enough, since the criteria satisfaction indices are rated to medium or poor levels. The main element causing dissatisfaction is "cleanliness", since the surveyed passengers assigned it with the lowest satisfaction rate (11.78%),

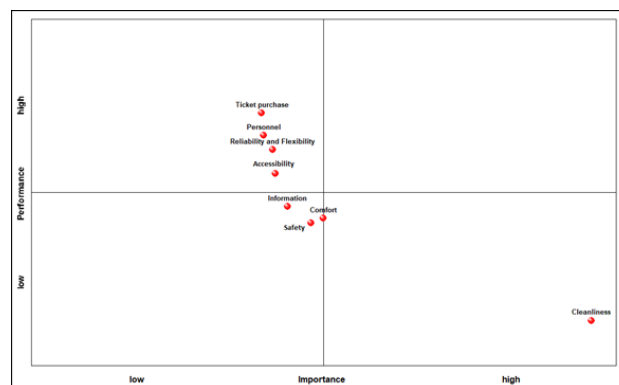
while the element scoring the highest appears to be the “ticket purchase” with the rate of 51.19%. The weights of the first-level satisfaction criteria are also presented in Table 1. The criterion of “cleanliness” appears to be by far the most important criterion for responding passengers at a rate of 28.15%.

Table 1. Criteria weights and satisfaction indices

Criteria	Weights [%]	Satisfaction Indices [%]
Safety	11.78	30.40
Cleanliness	28.15	11.94
Comfort	12.50	31.31
Ticket purchase	8.91	51.19
Information	10.40	33.49
Reliability & Flexibility	9.54	44.27
Personnel	9.03	46.96
Accessibility	9.69	39.70
Overall Satisfaction		33.01

As demonstrated in the action diagram below (Figure 2), there is no criterion rated as both of high efficiency and high importance, meaning that none criterion belongs to the leverage opportunity area, so as to serve as a source of advantage against competition. The only criterion that belongs to the action area of the map, having a low performance index, but scoring high in importance is “cleanliness”, and this is where all improvement efforts should be concentrated in order for the level of passengers’ satisfaction in Greek railways to be increased. “Safety” and “information” belong to the status quo, that is, the area of low performance and low importance and usually no further action is required. “Comfort” is located between the status quo and the action opportunity area. This implies that this feature may be shifted in the future to the action opportunity area and it can be critical for improving the overall passenger satisfaction. Finally, the satisfaction dimensions of “ticket purchase”, “reliability and flexibility”, “personnel”, and “accessibility” correspond to the transfer resources area, where the firm would better transfer the resources and efforts using for them into others considered more important by the customers.

Figure 2 Action Diagram for Greek railways



CONCLUSIONS

In the present paper, we developed a multi-criteria evaluation framework, aiming to measure passenger satisfaction in Greek railway services. This was accomplished by conducting extensive literature search guided by a Systematic Literature Review (SLR) process, following the determination of the 8 first-level criteria and 32 second-level satisfaction sub-criteria/dimensions that would be included in our proposed multicriteria framework. The evaluation process was based on the MULTicriteria Satisfaction Analysis (MUSA) method that has been extensively used in existing research for customer satisfaction analysis purposes. We then applied the proposed model in the case of rail passenger services in Thessaloniki, Greece. Analyzing the results, it has been revealed that Greek railway passengers exhibit a very low overall satisfaction in the order of 33.01%. The findings of this paper may be helpful for practitioners who can include important quality attributes to satisfaction measures on the basis of passengers’ perceptions, as well as design and implement strategies or programs towards improving passenger satisfaction and perceived level of service. Moreover, the

proposed multi-criteria evaluation framework can be easily generalized and applied in similar satisfaction analysis problems in rail or other transport modes in that they largely share similar quality attributes and satisfaction dimensions.

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A conceptual multi-criteria framework for understanding and assessing a smart city logistics ecosystem

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Abstract

Taking into consideration the digitalization of everything, global developments and the need for more sustainable and viable cities, there is an acute need for efficient and optimized urban supply chains. Although city logistics traditionally suffered from several operational inefficiencies and practical implementation challenges, mainly driven by the conflicting interests of the plethora of private actors involved and the limited role of public authorities, a new era for city logistics has recently emerged. Under the scope of the EU's policy agenda for CO₂ free cities and the promotion of smart cities, many European cities have started actively examining and demonstrating smart city logistics schemes. However, the lack of a thorough understanding of the city logistics ecosystem and the insufficiently explored research area of the smart city logistics ecosystem so far, are essentially hidden behind the lack of a holistic approach on designing a smart urban logistics environment and the fragmented implementation of short term solutions. In response to these gaps, this paper proposes a conceptual multi-criteria framework as a tool for: i) understanding in depth the main components of a smart city logistics ecosystem, ii) enabling the assessment of a city's level of smartness and iii) supporting the city logistics planning and monitoring process. The proposed framework consists of an extensive list of evaluation criteria, structured in four impact areas, namely Government, Economy, Actors, and Environment. The selected high-level criteria capture the main aspects of a smart urban logistics system and are further broken down into indicative qualitative assessment questions which constitute the ground basis for initiating a multi-stakeholder assessment process.

KEYWORDS

Smart city, city logistics, multi-criteria, assessment framework

INTRODUCTION

"Smart city" was introduced in literature in the 1990s, referring to a city that effectively deploys Information and Communication Technologies (ICT) in order to develop integrated and modern infrastructure (Albino et al., 2015). Following additional analysis on the topic, the research community seems to converge on the fact that the main success factor for a city to become "smart" is to effectively combine the human capital, the social capital and the use of Information and Communication Technology (ICT) infrastructure (Manville et al., 2014) for the implementation of smart and efficient solutions (Hong Kong Government, 2015). In terms of city logistics, following the global developments and the path towards the digitalization of everything, the need for secure, fair and sustainable city logistics operations implies the constant use of smart tools and techniques (DHL Trend Research, 2016). Due to the heterogeneous and business-oriented nature of the city logistics sector though, this fields was until recently unattractive to the policy makers. Recent evidence reveals that the public authorities lack of awareness on the current state of the city logistics sector in their city, its main characteristics and its general performance in terms of efficient and effective city logistics operations. Therefore, solutions for urban freight transport problems are usually fragmented and short-term, and unfortunately urban freight transport (UFT) operations are still considered to be rather inadequate (EC, 2013).

In general, little is known on how a city logistics system performs as a whole in terms of smartness and sustainability. Past evaluation experiences about the city's smartness and the effectiveness of the city logistics sector, focused either mainly on passenger transportation (Giffinger et al., 2007) or dealt with the ex-ante and ex-post assessment of specific city logistics initiatives. This paper aims to bridge this gap by providing a coherent multi-criteria framework for understanding in depth the main components and characteristics of a smart city logistics system and thereafter facilitating the assessment of its performance.

LITERATURE REVIEW

A smart city logistics system

Considering the global developments, the continuous growth of urbanization and consequently the significant increase of the demand for delivering products among citizens/companies within the urban environment, UFT constitutes a fundamental component of city life and the need for secure, fair and sustainable city logistics supply chains is higher than ever. Therefore, the integration of city logistics and urban freight transportation and its harmonization with the city's ecosystem signifies one of the main requirements for the achievement of smart mobility and subsequently setting a fertile ground for the development of smart city capabilities.

In general, the city logistics system is organized around three distinct components (Bektaş et al., 2017): i) the system's characteristics which are comprised by the urban freight demand, the existing facilities that are operated for facilitating UFT (e.g., urban consolidation centers, parking lots) (Dablanc, 2007; Panero et al., 2011), the layout of the system and mode/type of freight transportation, ii) the planning processes at a strategic, tactical and operational level of decision making (Bektaş et al., 2017) and iii) the appropriate business models for the development and viability of new initiatives and concepts in city logistics (ERTRAC, 2014; Dondi et al., 2017). Besides these three main components, though, the level of complexity of a city logistics system depends also on external factors, or else called "external influences" (Bauwens, 2015). These factors pertain mainly to future or existing trends that may affect the current operation of a city logistics system and may vary from economic factors, potential environmental factors, the demographics of a city, the availability of new technologies as well as regulatory factors (Global Commerce Initiative, 2016).

To address these city logistics problems and challenges, several new, innovative and smart city logistics schemes can be identified in literature driven by three main logistics megatrends identified by DHL Trend Research (2016): 1) digital solutions for raising security awareness, 2) direction towards new energy resources (e.g., alternative transport modes, multimodality) and 3) digitalization of everything, the increase of e-commerce and next hour/same day deliveries. However, on top of the deployment of smart techniques in operational processes implemented by the companies, the achievement of a smart city logistics system as a whole requires also the smart, efficient and effective urban freight transportation planning and the implementation of smart city initiatives by the governing bodies and local authorities such as cooperative planning, sustainable urban logistics planning, as well as availability of smart infrastructure (Taniguchi and Tamagawa, 2005; Taniguchi, 2014; Shao et al., 2019).

Assessing the performance of a city logistics system: Past experiences

Effective and efficient urban freight transportation planning implies the understanding of the current state of a city's Urban Freight Transportation (UFT) system along with its strengths and weaknesses. Obtaining a clear insight on the current performance of a city logistics system is still considered a challenge for the public authorities mainly due to the heterogeneity and business-oriented nature of the city logistics (Stathacopoulos et al., 2016). Even less is known about how a city performs in terms of "smart city logistics", not only because the term "smart city" is more recent or not extensively known (Giffinger et al., 2007), but also due to the fact that the ideal "smart city logistics system" has not been clearly defined yet.

More specifically, several attempts can be found in literature on the assessment and ranking of a city's smartness. Some indicative examples are the evaluation framework developed by Giffinger et al. (2007) and the "Smart City Wheel" developed by Cohen (2013). The main structure of these frameworks was based on a hierarchic model which was comprised by three main levels, with each level being further decomposed. More specifically, the first level consists of the six main sub-areas: smart economy, smart governance, smart living, smart people, smart environment and smart mobility; which are further analyzed in the second level by various factors. Griffinger (2007) identified 31 factors, while Cohen (2013) 18 factors which further split into the third and final level by numerous Key Performance Indicators (KPIs). The aforementioned efforts propose structured frameworks for assessing and comparing the level of "smartness" among cities, without specific consideration about the role of city logistics to the broader city ecosystem. It is, therefore, practically intractable to measure the impact of city logistics operations on the general performance of a city with respect to "smartness". The previous analysis reveals a gap on the current state of the smartness of a city's logistics ecosystem, by taking into account all factors that might influence the city logistics system, the main characteristics of a city logistics ecosystem, as well as the different stakeholders that are involved in this system (Tadic et al., 2018). In response to this gap, we herewith propose a comprehensive, multi-criteria conceptual framework in order to facilitate the deep understanding of a smart city logistics system and help the public authorities better monitor the smartness' of

their city's UFT portraying the complexity of city logistics systems in terms of the several factors influencing the city logistics system as well as the various actors involved.

A FRAMEWORK FOR UNDERSTANDING A SMART CITY LOGISTICS ECOSYSTEM

The structure of the proposed framework consists of four hierarchical levels, as schematically illustrated in Figure 1. Considering the smart cities classification proposed by Giffinger et al. (2007) and Cohen (2013) and the main characteristics and influencing factors of a smart city logistics system, the smart city logistics system is decomposed into four main impact areas, which constitute the 1st level of analysis and the foundation basis of the framework. Each impact area is further broken down into specific criteria and sub-criteria (2nd assessment level) which aim to clarify further the area of influence of each impact area and thus facilitating the understanding and monitoring of each area. These are described in what follows:

Impact Area 1 - Smart Governance: Capturing the availability of tools and resources of the public administration (Giffinger et al., 2007).

- **Criterion 1 (Smart Resources):** This criterion aims at assessing the smartness of the resources provided by the government related to the urban freight sector. In particular, these resources refer to the actions and tools provided by city authorities for 1) smart land use planning and infrastructure (Sub-criterion 1.1.): capturing the existence and development of appropriate infrastructure facilitating urban freight activities, as well as the provision of the appropriate tools for effective communication and information exchange among the UFT actors, 2) Smart UFT planning and regulatory measures (Sub-criterion 1.2.): understanding the activity of public administration towards the implementation of strategic and innovative regulatory measures for effective and efficient UFT, and 3) smart public services and administration (Sub-criterion 1.3): capturing the provision of transparent public services and administration.
- **Criterion 2 (Smart UFT Engagement):** A smart city and consequently a smart city logistics environment is highly interdependent on the level of engagement among the public and private actors. This criterion aims to identify whether public and private cooperative schemes exist in a city's environment and capture the general behavior and attitudes of the stakeholders towards changes and public initiatives in city logistics environment.

Impact Area 2 - Smart Economy: Capturing the UFT stakeholders' financial condition and strength as well as the general behavior of the UFT actors towards new technological developments and innovations.

- **Criterion 1 (Smart Productivity):** The economic stability and the financial condition of the UFT actors in general is one of the major factors that may influence the smartness of the city logistics sector (Gatta et al., 2017).
- **Criterion 2 (Smart Entrepreneurship):** This criterion examines the level of investment by the UFT actors on research and development activities and city logistics start-ups (DHL Trend Research, 2016).

Impact Area 3 - Smart Actors: Identifying the smartness of the city logistics actors in terms of responsiveness, responsibility and visibility of the UFT operations.

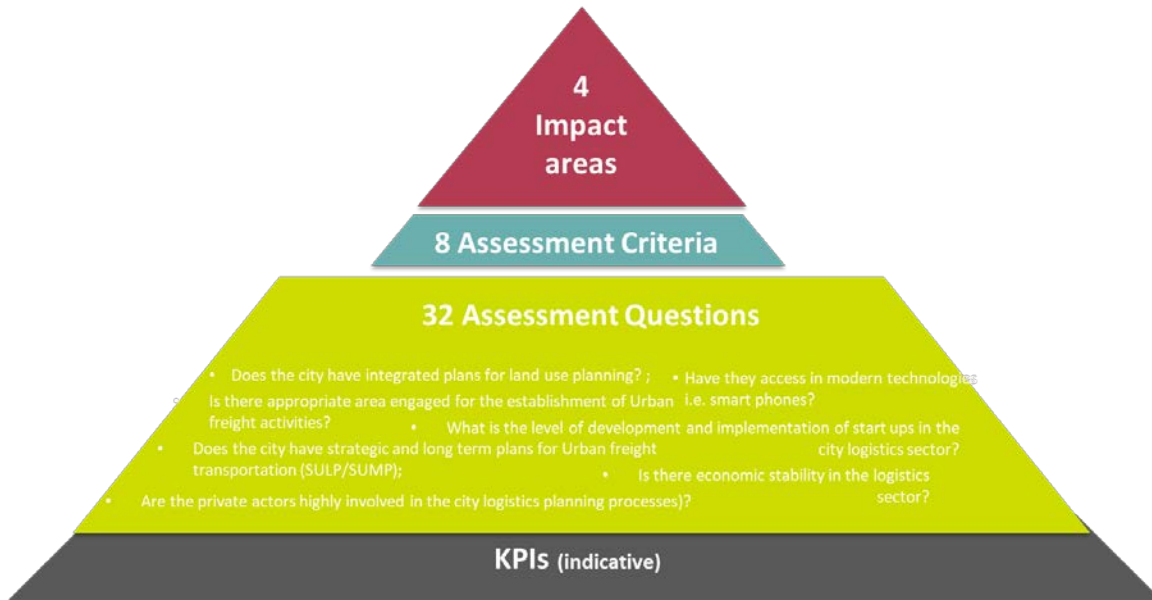
- **Criterion 1 (Smart UFT Operations):** It pertains to the identification of how smart the UFT actors operate, by measuring if the UFT stakeholders have access to modern technologies and use of smart tools such as Internet connected operations, e.g., use of smart devices for communication and data exchange, dedicated route guidance system, big data analytics methods for predicting demand and supply and analyzing the user preferences, use of cloud services for the facilitation of data exchange, in-vehicle safety systems, GPS, traffic flow prediction system, sensor technologies etc.
- **Criterion 2 (Smart Thinking):** This criterion focuses on the identification of the UFT actors' attitude towards innovative solutions such as the use of driverless vehicles for last mile distribution, 3D printing, unmanned aerial vehicles and their level of experience in using smart systems (DHL Trend Research, 2016).

Impact Area 4 - Smart Environment: Capturing the ecological awareness of the UFT actors and the extent to which a city promotes and uses environmental management techniques in UFT operations.

- **Criterion 1 (Smart Ecological Awareness):** This criterion deals with the identification of the ecological awareness of city logistics actors and their attitude towards developing synergies with other actors (e.g., cargo consolidation, shared logistics/warehousing) in order to minimize these impacts, as well as the use of alternative modes of transport or electric mobility for UFT operations.
- **Criterion 2 (Sustainable Planning):** The assessment of "sustainable planning" towards a smarter environment consists of two main sub-areas of interest. The first sub-area considers the identification of the current situation of the city in terms of air and noise pollutants due to UFT operations, while the second sub-area addresses the activities of governmental bodies for facilitating and motivating the UFT actors to achieve more environmental-friendly UFT operations.

Following the identification of the main criteria and sub-criteria describing the main impact areas, the subsequent two steps/levels of analysis provide answers as to how these criteria can be expressed and measured in terms of qualitative assessment questions and key performance indicators (KPIs) for a more quantitative analysis.

Figure 1. Hierarchical Structure of the Proposed Framework



CONCLUSIONS

The herewith presented paper introduces a multi-criteria framework for understanding in depth the main components and characteristics of a city logistics system and facilitating the assessment of the level of smartness of a city's city logistics system. The proposed framework consists of four hierarchical levels. The first level of analysis defines the key impact areas, while the second addresses the main criteria and sub-criteria describing further the key impact areas. The subsequent two levels aim to further support the measurement process by expressing the criteria in the form of either qualitative assessment questions or quantitative KPIs. As part of our future research, the proposed framework will be further elaborated with respect to the last two levels of analysis, and will be complemented by a detailed roadmap describing how to apply it as a benchmarking or self-assessment tool.

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Ranking of importance of the most important social media platforms in hospitality and tourism

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Abstract

Tourism is the "heavy industry" of Greece as it is the main pillar of the country's economic development. In recent years the use of the internet and social media usage, have diversified and transformed the way businesses promote their services to potential consumers. The development of online promotion combines the use of modern technological platforms, like the social networks (Facebook, MySpace, LinkedIn), blogger blogs (WordPress), micro-blogging (Twitter) and wikis (Wikipedia, Wikinews). By having that in mind the specific work aims to examine the use of social media in the hospitality industry in terms of analyzing the impact to consumer decision making perspectives.

In doing so, we have collected data from Greek tourism entrepreneurs, where they ranked and assessed the relative importance of the main social media platforms in order better to understand the impact they have on the consumer decision-making process. To that extent, we have used the methodology of multicriteria analysis, and specifically the outranking method PROMETHEE II. Finally, a thorough discussion and conclusions are given to different research practitioners and policy makers.

KEYWORDS

Tourism, digital marketing, social media, PROMETHEE, Greece

INTRODUCTION

The evolution and development of the internet through the use of E-commerce affected and changed the way of consumer buying decision processes. Nowadays, consumers can find easily products and services that best suits to their needs. Specifically, in the last decade, the evolution of digital marketing helps businesses in the hospitality industry and tourism sector to manipulate more effectively their advertising practices. As such, firms tend to frequently communicate with customers through the use of social media platforms. It can be argued that social media users are numerous around the globe and are constantly growing, with most of them spending a lot of time daily dealing with social networking platforms (Hennig-Thurautal, 2010; Fadzil and Yusoff, 2015). Thus, businesses build more effective communication strategies.

One of the advantages of advertising using social media is that there is no restriction on the firms' operational size that uses these means. However, it is necessary for each company to organize its own strategic plan with regard to the actions it will take in the context of its advertising on the web and the selection of the most appropriate social networks that will lead them to the desired measurement results, such as key performance indicators (KPIs) for viral marketing, electronic word of mouth, and other mobile commerce activities. Overall, the potentials of the social media use in the Greek tourism sector has not been fully explored yet. Social media play an important role in measuring the effectiveness of marketing strategies with the use of search engine optimization (SEO), marketing (SEM) and pay-per-click marketing (PPC). Thus, the aim of this research is to rank the most important social media platforms used in the tourism and hospitality sector.

LITERATURE REVIEW

The tourism sector is one of the largest industries in the world, often surpassing the automotive industry, the iron and agricultural sector. It is estimated that tourism accounts for 3.6% of world consumption (WTTC, 2020). Specifically, in Greece, the tourism sector in Greece occupies around 1.000.000 workers. Also, the total GDP participation is 30.9%, while total revenue from tourism amounts to 15.6 billion. Most international customers prefer to visit Greece during the summer months, i.e., from June to September (54.8%), with most tourists spending 520 euros (ELSTAT, 2020). The data of the Hellenic Statistical Authority show that tourist arrivals from abroad, estimated at 2019 to 28.7 million, an increase of 5.5% compared to 2018 arrivals. By analyzing the tourist choices, it seems that hotel accommodation has

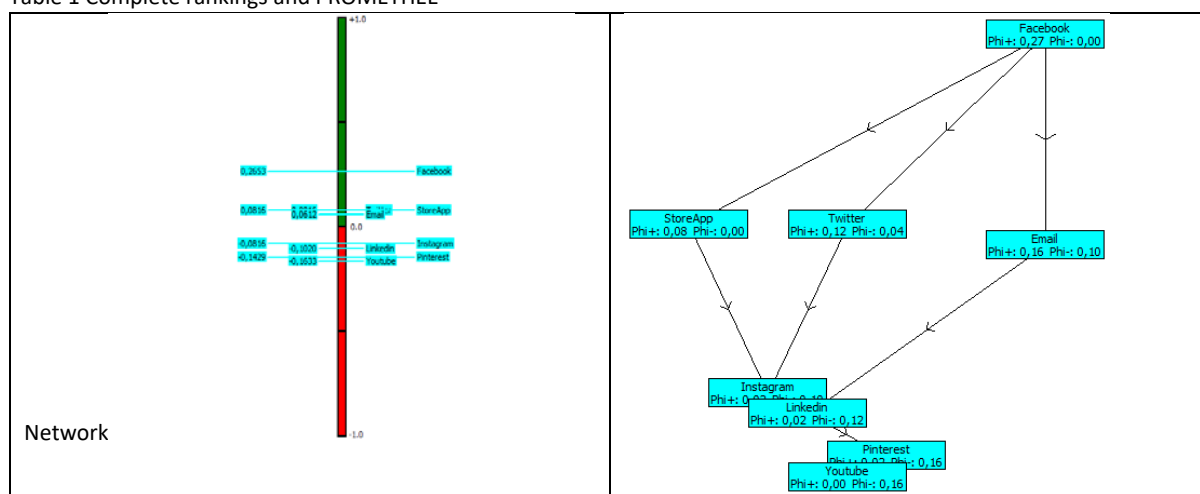
increased by 2.6%, while accommodation in rooms for rent, increased by 6%, while at the same time there were no significant changes in camping accommodation since it increased only by 0.5% (ELSTAT, 2020). According to Borges (2009) there are four stages of user interaction with social networks. The first stage is the “participation”, which should be frequent and stable in order to increase the interaction with the public. The second stage relates to the extent in which the company “listens” to user comments on its webpage, whether positive or negative, treating each user with seriousness and respect. In this way the company shows its users and prospective future customers that it is interested in building relationships of trust. The business should then maintain an interactive relationship with users. For example, the posting of a photo or information about a product or service can trigger a conversation around it, with users like/share. Thus, the public shares this information through notifications with other online users, resulting in more direct dissemination of the information to relevant consumers’. The last step is to measure the impact of each online promotion action to the public, as well as to control the achievement of the company's objectives. These goals may be related to the increase in comments on the web page (Borges, 2009; Buhalis, 2000; Misirlis and Vlachopoulou, 2019; Bergemann and Bontatti, 2011; Evans, 2009). In addition, in order to gain a long-term presence in the internet, a business page should communicate regularly with the social media users (Fischer and Reuber, 2011; Balakrishnan et al., 2914). In the modern age social media platforms are numerous and so the work of researchers to classify them into specific categories is becoming increasingly difficult (Laroche et al., 2013). One way for researchers to classify them in a particular category is on where they are based. These categories are the social networks (Facebook, MySpace, LinkedIn), blogs (blogger, WordPress) micro-blogging (Twitter, Tumblr) and wikis (Wikipedia, Wikinews). This diversification leads to the creation of social media based on image (Photobucket), videos (YouTube, Dailymotion, Vimeo), and music (MySpace Music). There are also those that rely on a certain function such as live broadcast (Skype) and other bookmark links (Mangold, 2009).

METHODOLOGY AND DATA ANALYSIS

The study population included nine (9) entrepreneurs who have established Hotel organizations in Northern Greece and we used the technique of qualitative in depth-interviews, where they examined and ranked the common criteria of different social media platform-characteristics. For example, interviewees were asked to assess the most commonly used social media platforms and their impact in the consumer decision making process. Furthermore, the data were analyzed with the use of multicriteria decision-aid analysis and the software of PROMETHEE II (Brans and Mareschal, 1994).

Table 1 shows the complete rankings of the alternative actions. We can analyze the actions according to Phi+ preference flows. It should be mentioned that the Phi scores show the incomparability between actions which determines the decision-makers to focus on these variables (Brans et al., 1986).

Table 1 Complete rankings and PROMETHEE



Based on the respondent scores for the use of social media, it can be seen that the first ranked action is the use of Facebook, followed by Store App, Twitter and Email. Further, we examined with decision-makers the evaluations of the

relative importance of the impact of social media on the consumer buying decision process and we found that these actions have greater impact to consumers when searching alternative information before the actual purchase, i.e. to select a suitable hotel.

DISUSSION AND CONCLUSIONS

The use of social networking platforms, such as Facebook and Twitter, creates the link that unites businesses in the hospitality industry in a variety of different ways. These tools encourage businesses to engage in technology, provide people with new knowledge, introduce new ways into the trade and facilitate relationship with customers. Of course, from the above data it seems that the exploitation of these social media tools by businesses is at an early stage. However, the use of social media platforms should be applied wisely targeted their advertisements to consumers as it may create a negative impact, like it can cause the disappearance of important information and data as well as cause problems in the company's systems.

Hotel organizations should try to keep the company's website up to date. The hotel's new amenities and offers are often posted, and guests are immediately informed about these offers via informational emails and text messages. As such managers in order to make the enterprise sustainable over time, it is necessary to implement strategies that interact with customers daily through the use social media. Facebook is the most important tool to promote the services offered and easily can attract the interest of new customers and tourists. We can conclude, that through Facebook, hotel managers can understand the needs and interests of users by creating corresponding posts and interactions with their targeted groups. In particular, the social media use is proven to change the way businesses facilitate their communication strategies.

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Multicriteria Based Analysis on the Type and Capacity of Hotel Accommodation: Classic Vs All Inclusive Hotel

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Abstract

The need to compare Classic and All-Inclusive Hotels as two types of hotel operation at a technical and quantitative level and their corresponding capacities was the focus of the present study. Initially, specific reference sizes were selected regarding the dynamics of the hotels based on their capacity in rooms and the level of services offered. It was ensured that the defined sizes represented similar products to the tourism market and therefore competitive alternatives. In terms of capacity, three reference hotel sizes were selected (400, 280, 150 rooms), while the services offered were defined in all cases as luxury five-star summer vacations. The types of hotels considered in the current research included: All-Inclusive 400, All-Inclusive 150, All-Inclusive 280, Classic 400, Classic 150, Classic 280. A detailed description of the construction needs of the alternative hotels in each case was analyzed. Then, the cost of construction was examined in detail for every considered hotel with a detailed recording of the differences between alternatives. An additional group of criteria focused on the cost of operation. After analyzing the various components that make up a hotel, regardless of size, the operating costs were considered for each case. Therefore, it is possible to directly compare alternatives based on real numerical data. Multicriteria analysis was employed using PROMETHEE method. In this case, the plethora of alternatives that are reflected in the different operating standards and sizes of the hotel units, makes the multi-criteria analysis an ideal approach for ranking the selected hotel units. Ten criteria are introduced, with the corresponding weights assigned to each of them, as assessed by a panel of experts. Visual PROMETHEE suggested that the "Classic 150" was the best alternative, followed by "Classic 280" and then "All-Inclusive 150" according to research team assessment. On the other hand, experts' panel assessment ranks first the "All-Inclusive 400" and last the "Classic 150".

KEYWORDS

Multicriteria Analysis, Hotel Management, All-Inclusive Hotel, Classic Hotel, Visual PROMETHEE.

INTRODUCTION

Greece relies heavily on tourism for the economy to grow. New hotel facilities and infrastructure to accommodate customers require careful planning and operation. Nowadays it is very important to choose the correct type of operation and hotel capacity. Therefore, the current study provides a methodological approach for the selection among All Inclusive and Classic hotels and for decisions regarding the hotel capacity. The paper's following sections include a brief presentation of multicriteria techniques, methodological approach, PROMETHEE implementation and finally conclusions and further research.

MULTI-CRITERIA DECISION ANALYSIS AND PROMETHEE

Helping people make informed and, hopefully, better decisions is the prime concern of decision making (Keeney, 1992). With Multi-Criteria Decision Analysis (MCDA), it is possible to overcome many of the weaknesses of traditional evaluation methods as it allows factors that cannot easily be quantified or expressed in monetary terms, but nevertheless play a decisive role in shaping the policy (Roukouni, 2016).

Moreover, MCDA evaluates the alternatives by combining both quantitative and qualitative criteria (Vincke, 1992). A significant number of methods have been developed, including Multi Attribute Utility Theory (MAUT) (Von Neumann and Morgenstern, 1947), ELimination and Choice Expressing REality (ELECTRE) (Roy, 1968), Analytical Hierarchical Process (AHP) (Saaty, 1977), Preference Ranking Organisation METHod for the Enrichment of Evaluations (PROMETHEE), (Brans et al., 1986), Verbal Decision Analysis (Larichev and Moshkovich, 1997).

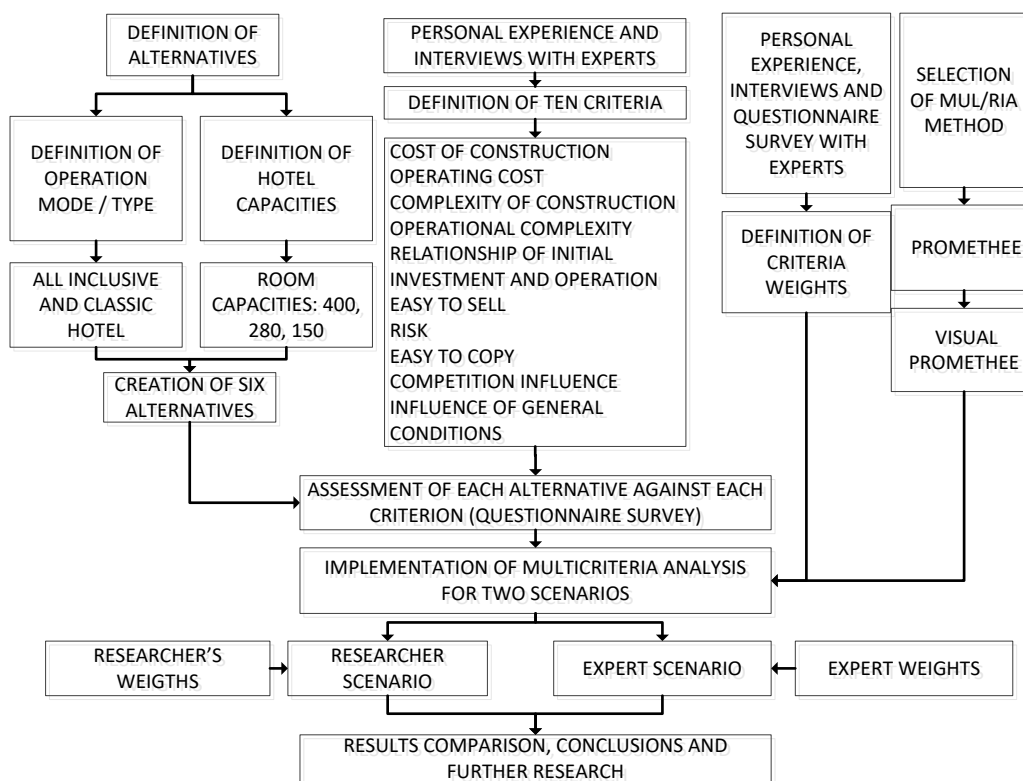
The selected method for the current analysis is PROMETHEE. This method has been used particularly in transport, but also in many applications in different fields, such as environment, health, water resources, tourism, etc (Roukounis et al., 2020)

PROMETHEE method, was considered more advantageous in the current study. The reason is that it helped overcoming the interdependencies requirement and at the same time included the various stakeholders' participation in the evaluation process through the provision of a more simplified, vastly limited and more easy to use evaluation matrix (Gagatsi et al., 2017) cited in (Roukounis et al., 2020).

Methodological Approach

The aim of the current study is to propose a tool to facilitate all decision makers, stakeholders, investors into selecting the operational type and capacity of a luxurious five-star hotel. In this context, a number of case studies were considered that included All Inclusive and Classic hotels, with varying hotel capacities. Ten criteria are defined and their weights are assessed by two different parties. The weights are evaluated based on the experience of the research team and then based on a panel of experts through a structured questionnaire survey. The performance of each hotel against each criterion was again evaluated with the aid of experts and again through a structured questionnaire survey. Visual PROMETHEE was implemented twice both for the research team and the experts in order to rank the available hotels. The current methodological approach is presented in the following Figure 1 flowchart:

Figure 1. Methodological Approach



Application and Results of PROMETHEE Methodology

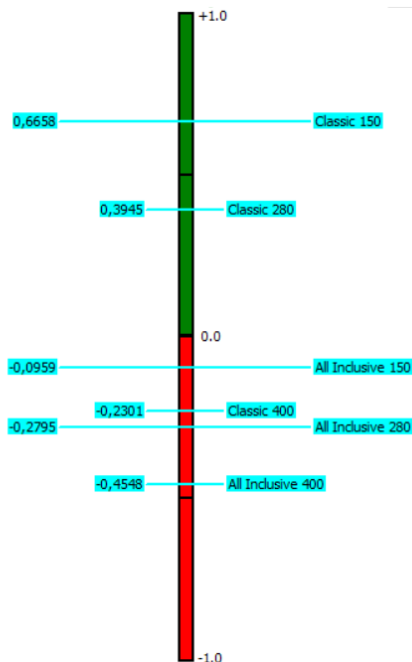
In the context of the current research two scenarios were considered. The first one was based on the research team assessment of the criteria weights and the second approach considered the evaluation of the weights produced by the team of experts. The weights (significance) assigned by each group is presented in the following Table 1.

Table 1 Criteria Absolute Weights based on Research Team and Experts

	CONSTRUCTION COST	OPERATION COST	COMPLEXITY OF CONSTRUCTION	OPERATIONAL COMPLEXITY	RELATIONSHIP OF INITIAL INVESTMENT AND OPERATION	EASY TO SELL	RISK	EASY TO COPY	COMPETITION INFLUENCE	INFLUENCE OF GENERAL CONDITIONS
ABSOLUTE WEIGHTS Research Team	8,63	8,38	7,50	6,88	7,63	6,88	6,88	6,25	6,75	5,50
ABSOLUTE WEIGHTS Experts	9	8	8	7	8	7	7	6	7	6

A quick look at the Table 1 shows that the research team tend in most cases to assign weights that vary. In the case of Experts weights tend to be equal in a lot of criteria. In addition, it seems that there is an agreement to the most and less significant criteria among the two groups. These variations in the criteria weights produce a number of variations in the ranking of the alternatives. These are becoming apparent in the following figures. The following figure 2 presents the PROMETHEE Complete Ranking as a result of the analysis for the scenario based on the Research Team assessment. It is obvious that Classic 150 is the best choice while All Inclusive 400 is last among the alternatives.

Figure 2 PROMETHEE Complete Ranking (Research Team)



More detailed information is provided within Table 2 that presents the PROMETHEE Flow Table. It is worth mentioning that the net flow of the best alternative namely Classic 150 is almost double than the second in rank alternative (Classic 280).

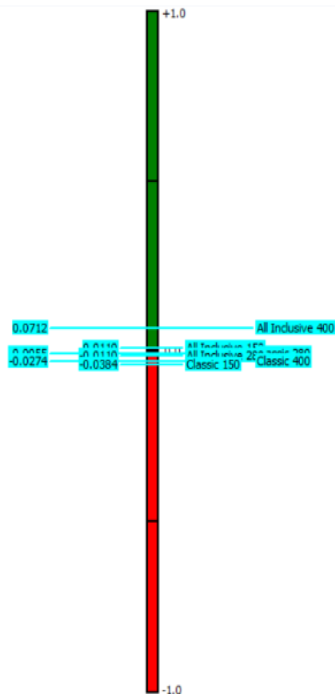
Table 2 PROMETHEE Flow Table (Research Team)

Rank	action	Phi	Phi+	Phi-
1	Classic 150	0,6658	0,7507	0,0849
2	Classic 280	0,3945	0,6192	0,2247
3	All Inclusive 150	-0,0959	0,3041	0,4000
4	Classic 400	-0,2301	0,3178	0,5479
5	All Inclusive 280	-0,2795	0,2466	0,5260
6	All Inclusive 400	-0,4548	0,2192	0,6740

Similarly, the following Figure 3, presents the PROMETHEE Complete Ranking, based on the experts' point of view. It becomes apparent that the order of alternatives has changed. More specifically, in this scenario, All Inclusive 400 is the

best choice according to this scenario. One very interesting finding is that the Classic 150 is ranked last in this scenario. It should also be mentioned that in the current scenario, all alternatives are extremely close as far as the total Phi is concerned.

Figure 3 PROMETHEE Complete Ranking (Experts)



Similarly, Table 3 which presents the PROMETHEE Flow Table based on the experts' scenario confirms Figure's 3 findings. Similarly, with the previous scenario, only two alternatives have positive net flow. In this scenario, all the alternatives are very close together regarding their net / total flows. It is worth mentioning that the values of Phi+ and Phi- in all alternatives are very close together.

Table 3 PROMETHEE Flow Table (Experts)

Rank	action	Phi	Phi+	Phi-
1	All Inclusive 400	0,0712	0,2055	0,1342
2	All Inclusive 150	0,0110	0,2027	0,1918
3	Classic 280	-0,0055	0,1534	0,1589
4	All Inclusive 280	-0,0110	0,1397	0,1507
5	Classic 400	-0,0274	0,1863	0,2137
6	Classic 150	-0,0384	0,2301	0,2685

CONCLUSIONS AND FURTHER RESEARCH

All Inclusive's popularity is largely due to the fact that it provides customers with a great variety. The introversion that this model presents, makes it more suitable for a larger infrastructure so that it can include a variety of options but also to avoid the feeling of a mass product. In contrast, classic luxury hotels win over their customers with their privacy and adaptability to their needs. They are particularly extroverted as they encourage visitors to discover the area in which they are located. Therefore, a small, luxurious and construction-exquisite unit seems preferable.

The cost difference between the same standard operating units is mostly proportional to the size of the unit. The big difference is observed between the two standards as the incompatibility at the level of facilities concerns a whole group of infrastructure and not an increase or decrease in their size.

The so-called soft costs are a very important factor in the construction of a project. It needs special attention and care as their intangible nature facilitates significant deviations (increase) in their value.

In case a hotel is chosen to be built from scratch, the costs of demolition and reinforcements are bypassed. However, it is common for large units to choose the method of reconstruction of an existing unit as it means time savings and more favorable urban planning conditions and regulations.

It is observed that the respondents assigned significant importance (greater weights) to the construction and operation costs, which confirms the need for a detailed planning.

The location plays a key role for the success of any tourism investment. Although in the present study the candidate hotel was considered to be in an ideal position, the importance of this necessary assumption should not be overlooked. Limitations of the current research include the following:

- Operating costs expressed in this study through a percentage of the initial investment, is a key element of a hotel's success and is worth studying in more detail
- In the present research, a luxury hotel complex is investigated in depth. It is important to adapt the criteria in case the quality required by the entrepreneur is different
- It was considered that the site for the construction of the hotel is available and its cost is unclear. It is obvious that in a more detailed analysis, this factor alone could upset many balances
- This work deals exclusively with seasonal holiday hotels. This type of hotel has little in common with twelve-month city hotels, which require different approach.

Proposals and further research include but are not limited to the following:

- The state, from its part, must not only recognize the offer of the tourism industry in the country but also support it in practice, in various ways and constantly. Through a meaningful dialogue with industry and entrepreneurs, it will be able to create the right conditions in terms of legislation, so that they do not lag behind the other, competing countries.
- It is also considered very important to review the standards of Greek Tourism Organization, in order to keep pace with the latest trends and requirements in the tourism sector. Only after a review of all the sizes and standards could this proposed methodology evolve to be a valid and useful tool for decision makers
- Perhaps the most important state intervention should take place in the field of education. In the coming years, Greece must create educational departments of higher education, top level and directly competitive with the foreign ones. A country with such a great competitive advantage should only be a global pole of attraction in tourism education.

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Session 14: Machine Learning

chair: Georgios Aretoulis

Construction Equipment's Residual Market Value Estimation Using Machine Learning

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Abstract

This study focuses on the identification of the patterns, in which the residual market value (RMV) of construction equipment (CE) is being evolved through time. One of the nine foundational technology advances that Industry 4.0 has brought to humanity is the use of big data analytics, through machine learning techniques. In the domain of CE, this entity of data exists for many decades. Yet, the knowledge that could be extracted from this data is untapped, while great CE manufacturers, owners or dealers, are unstoppably gathering tons of information, concerning ownership, operation and maintenance costs. This study focuses on the ownership cost and more specifically on the identification of the patterns, in which the residual market value (RMV) of CE is being evolved through time. RMV of a machine when sold at any point in its life is an unknown that depends on many factors. This study presents a prediction model for RMV of excavators. A database is created using market information from equipment owners, CE manufacturers, CE auctions and it is used as a "test bed" for the prediction model. The model was developed with the use of RapidMiner Studio software. The results reached a very good level of accuracy in estimating residual market values.

KEYWORDS

Construction equipment, machine learning, residual market value, excavator.

INTRODUCTION

According to Vorster (2009), the RMV of a machine when sold at any point in its life is an unknown that depends on many factors. One of these factors is the CE market. So, this study collects the resale and auction prizes of 585 Caterpillar excavators (38% small, 34% medium and 28% large size), manufactured between 1980 and 2019, in order to proceed to their RMV estimation through ML techniques and compare them with their current RMV. Equipment data were found on the most popular internet sites for sales and auctions, such as constructionequipmentguide.com, euroauctions.com, machinerytrader.com and catused.cat.com. Equipment records concerned the global market for the year 2019. Those records were collected and classified according their type, size, manufacturing year, effective hours and their current RMV, resulting a database consisted of 585 records. ML was implemented using RapidMiner Studio software. Among various ML capabilities, RapidMiner offers the Auto Modelling ability. The user provides the necessary data and defines the prediction attribute, following detailed instructions. The main goal of this study is to identify the patterns under which the CEs' RMVs are evolving, under demanding market rules, and to present robust estimations of RMVs.

LITERATURE REVIEW

Several studies were published related to the examined topic. These are summarized and categorized, according to their research area, in Table 1.

METHODOLOGY

Statistical analysis

The selected attributes of the constructed database are: a. Type, b. Size, c. Manufacturing Year (MY), d. Effective Hours (EH) and e. Current Residual Market Value (CRMV). A statistical analysis was performed for the imported dataset of records. The most common appearances (333) are for excavators with RMV varying from 1.850 to € 85.000 €. 164 between 85.000 € and 167.816 €, 57 between 167.816 and 250.799, 19 between 250.799 and 333.782, 3 between 333.782 and 416.765 (Figure 1). Most of them are almost new equipment with few EHs. The most sold excavator types are 336FL and 349FL, while the majority is small sized. The most available equipment in the market and in auctions are those manufactured between 2011 and 2015, revealing that most of construction companies are replacing their equipment approximately up to 8 years of use (Figure 2). Equipment's EHs are varying, from 10 hours (new equipment) to 24.000 hours (very old or over-used equipment). The majority operated for about 100 to 1000 hours. As expected, the more EHs the less CRMV, the trend becomes steeper for large sizes excavators.

Machine Learning Model

The goal of the machine learning model development is to study the RMV fluctuation. RapidMiner's Auto Modelling ability offers sufficient capabilities to accelerate the process and analyze the extracted results. It develops ML models, depending of the imported data type, allowing the user to interfere during the process, in order to elaborate deeper and make any necessary changes.

After importing the database, RapidMiner evaluates the quality, the characteristics, and the diversity of the data. It presents an analysis for the above, indicating which are suitable to be exploited for ML and prediction and which are not (e.g. data presenting large deviations). RapidMiner uses specific quality indicators for this data evaluation: a. Correlation, for data categories very close to the prediction goal or for those that are irrelevant, b. ID-ness, for attributes that all their data are completely different, c. Stability, for attributes that have a great percentage of the same data or values and d. Missing, for data categories with absence of values (Figure 3). At the final stage, the software proposes several predictive ML models. The user can compare the performance of each model and decide which is the best, depending on the relative error, the standard deviation, training time.

There are three choices for applying ML to the imported database: prediction, clustering and finding outliers. This research focuses on RMV prediction. For the dataset concerning small-sized excavators (217 records), the reliability evaluation of RapidMiner concludes that three attributes are suitable for ML (Size attribute is excluded). The results are showing an ID-ness percentage of 95,85%, which for the EH attribute indicates that almost none of the equipment has the same number of effective hours. The literature supports that the effective hours of construction equipment are a crucial factor for estimating residual values. In order to assist RapidMiner in ML, the data of the efficient hours attribute were rounded to hundreds that concluded in an ID-ness of 31,80%, which is highly acceptable (Figure 3). The machine learning techniques used are: a. Generalized linear model, b. Decision tree analysis, c. Deep learning, d. Random forest, e. Gradient Boosting trees and f. Support vector machine.

The results are presented on a table form summary (Table 2) and the best method is been proposed, according to the best performance (due to the minimum correlation), the minimum scoring type and the minimum total time (scoring + training), for each of the five types of error: a. for the Mean Squared Error (MSE), a risk function and a measure of the estimator's quality, which measures the average of the squares of the errors, that is, the average squared difference between the estimated and the actual value, b. for the Root Mean Squared Error (the root of MSE), which is a measure of accuracy, to aggregate the magnitudes of the errors in predictions for various times into a single measure of predictive power, by comparing forecasting errors of different models for a particular dataset, c. for the Absolute Error, which sums up the absolute values of the differences between labels and predictions and divides this sum by the number of examples, d. for the Relative Error, which is the average of the absolute deviation (error) of the prediction from the actual value divided by the actual value, and e. for the Correlation, which describes the strength of relationship between two numeric attributes in a data set and also the direction of this relationship (positive, negative or none). The error comparison for each ML model is depicted on Table 2, where the bold value represents the proposed ML model with the best performance.

Table 1 Previous studies of machine learning application on estimating construction equipment’s RMV

Authors	Year	Title	Contribution
Michell	1998	A Statistical Analysis of Construction Equipment Repair Costs Using Field Data & The Cumulative Cost Model	By using field data on 270 heavy construction machines, he identified a regression model that can adequately represent repair costs in terms of machine age in cumulative hours of use.
Lucko	2003	A Statistical Analysis and Model of the Residual Value of Different Types of Heavy Construction Equipment	Through multiple linear regression analysis, he performed a residual value prediction, by using auction sales data and heavy construction equipment manufacturers’ publications.
Lucko et al.	2006	Statistical Considerations for Predicting Residual Value of Heavy Equipment	Identified the factors that affect the residual value of a construction equipment and they examined them comprehensively by analyzing real market data from equipment auctions, about track dozers.
Fan et al.	2008	Assessing Residual Value of Heavy Construction Equipment Using Predictive Data Mining Model	Stressed the importance of predicting the residual value of heavy construction equipment to an acceptable level of accuracy, to maximize the return of this investment. They introduced a data mining-based approach for estimating the residual value of heavy construction equipment.
Fan and Jin	2011	A study on the factors affecting the economical life of heavy construction equipment	They managed to extract rules leading to different cost patterns and therefore different economic life spans of heavy equipment, more effective maintenance strategies and to an accurate comparison among the equipment cost performance from various classes, makes and amount of service during their life cycle.
Spinelli et al.	2011	Annual use, economic life and residual value of cut-to-length harvesting machines	They gathered a large database of second-hand machine sale offers and conducted a statistical analysis. They concluded that the equipment’s residual value is strongly related to machine age.
Bertoni et al.	2017	Mining Data to Design Value a Demonstrator in Early Design	They applied data mining algorithms on a dataset build on a wheel loader’s performance and contextual and environmental data. They focused their estimation on the fuel consumption of alternative design concepts and estimated the performance variations given different contextual variable.

Table 2 Error comparison for each ML model (Small size excavators)

Model	Root Mean Squared Error	Absolute Error	Relative Error	Mean Squared Error	Correlation
Generalized Linear Model	16.525,172	12.712,893	27,6%	276.520.468,051	0,843
Deep Learning	23.813,024	19.024,513	34,5%	572.403.438,756	0,759
Decision Tree	24.194,310	13.085,769	32,3%	595.127.283,606	0,706
Random Forest	22.657,359	17.702,977	31,9%	537.351.256,470	0,613
Gradient Boosted Trees	21.142,293	12.452,851	22,7%	482.164.304,149	0,781
Support Vector Machine	24.746,419	20.507,590	35,8%	623.905.678,119	0,766

Figure 1 Equipment distribution based on their RMV

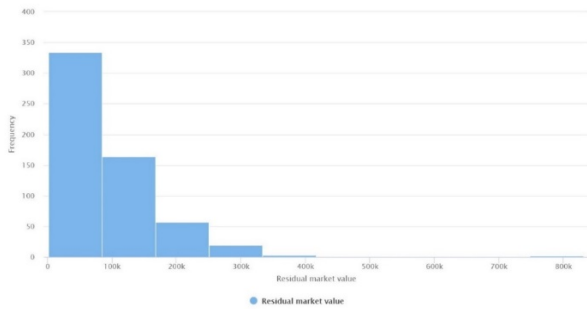


Figure 2 Quantity of excavators per manufacturing year

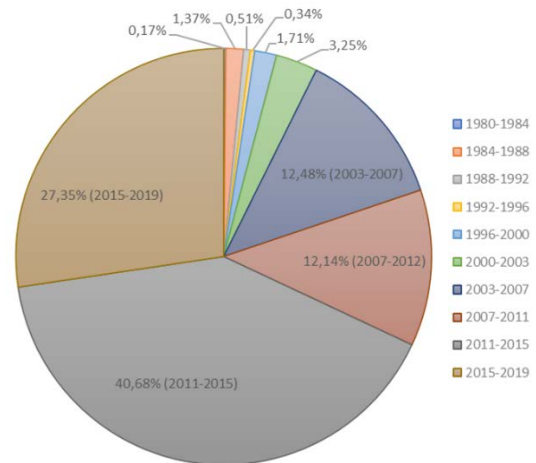
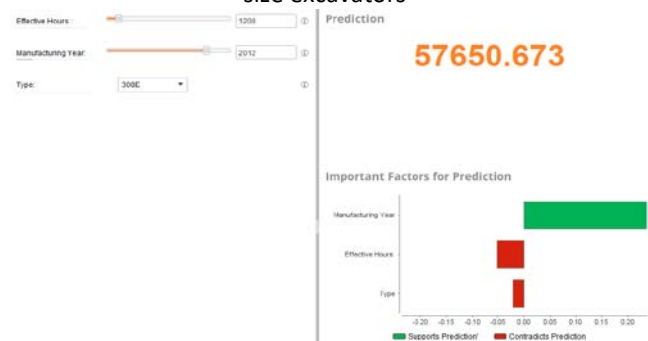


Figure 3 Rounded data evaluation for small size excavators

Select	Status	Quality	Name	Correlation	IDress	Stability	Missing	Test cases
			Size	7	0.0%	100.0%	0.0%	2.0%
			Type	40.3%	27.0%	10.14%	0.0%	27.2%
			Manufacturing Year	22.2%	12.3%	14.2%	0.0%	0.0%
			Effective Hours	1.2%	31.8%	5.4%	0.0%	0.0%

Figure 4 Generalized Linear Model – Simulation for small size excavators



Each technique attributes different weights to the predictors (the input parameters). The software incorporates an operator that provides statistical and visual observations to help understand the role of each parameter on Estimated EMV (ERMV). This role can be supporting or contradicting the estimation and is visualized with different color variations in red and green, as shown in the example generalized linear model simulation for small size excavators in Figure 4. In this example, the current RMV of the small-sized Caterpillar Excavator 308E, manufactured in 2012, with 1200 effective operating hours, should be 57.650 €, whereas in the market is found at 62.500 €; in this case the model provides a rather pessimistic approach regarding RMV. The ML algorithm recognizes the importance of the equipment’s manufacturing year, which supports the RMV prediction (green color), while its effective hours and type are contradicting the estimation (red color).

CONCLUSIONS

This study presents an innovative approach on predicting the RMV of construction equipment, by using advanced ML techniques, through RapidMiner Studio software. The construction equipment’s RV is one of the most dominant factors on determining the ownership cost. It signifies the need of applying a predefined and well-planned construction equipment replacement strategy for the equipment owners, taking into account current construction equipment market and auction trends. RapidMiner Studio analyzed a database consisted by 585 Caterpillar excavators, fed the ML algorithms, trained it, and presented a series of RMV results. A comparison between several types of predicting errors, training, and completion times, allowed the software to propose the generalized linear model as the most efficient ML method. The most dominant factor for predicting the equipment’s RMV revealed to be the equipment’s manufacturing year, while its effective hours were less affecting. For some older equipment, the ML model predicted negative values, reflecting the absence of a replacement strategy from their owners, leading the equipment to total depreciation (to “grave”). For others, the model presented great differences between the predicted and the current RMV, mainly for two reasons: a. some equipment types have fewer records inside the database and b. the current RMV is not a mathematically calculated value, but it is determined by the market itself and the law of supply and demand, confirming that the economic situation of the country and the indexes of construction output can determine markets trends.

ML models could be used for predicting the RMV of any kind of construction equipment. The creation of an extended database for all the types of construction equipment, with an increased number of attributes, such as operating conditions, type of works, manufacturer and other qualitative characteristics, could offer a very useful tool for equipment owners with robust cost predictions of their fleet.

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Finding the Best Path in HR Satisfaction by Using Structural Equation Modeling, Bayesian Networks, and Decision Trees

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Abstract

Every company searches, implements, and invests in new, more effective, and more efficient ways to recruit new personnel. They use all the methods available, like conducting consecutive interviews, using different kinds of testing environments and programs, searching thoroughly the candidates' practical and theoretical knowledge, testing hard, soft, and digital skills etc. All these ways are costly for companies because they should make absolutely right decisions about human resources selection to maximize the efficiency of selection procedure. This paper explores the ways that a company should make such decisions, by using machine learning methods. To do this, in first place, structural equation modeling, following by the Bayesian Network are used. To cross validate the results and paths of the previous methods, the decision trees method is used, which is a machine learning algorithm that analyzes the data concerning human resources selection and produces a graphic tree about key point decisions that should be made, depending on some specific values and bounds of different kinds of metrics, which actually help the company decrease its expenses and increase its performance. The main target of this work is to identify as best possible, the factors that affect job satisfaction of the personnel. Factors, like the likelihood of successful training with the minimal cost and in the shortest time period, and the possible work performance development, are important areas in this research. It is considered that this work will have a strong impact on how candidate testing and selection should be done. To the best of our knowledge, there has not been, so far, a work to relate machine learning with human resources selection.

KEYWORDS

Machine Learning; Human Resources; Decision Trees; Structural Equation Modeling; Bayesian Networks

INTRODUCTION

A successful strategy in HR selection is the most crucial factor for every organization in hiring skilled employees in order to be effective and efficient in their jobs. In general, there are two kinds of recruitment: (i) internal recruitment, which takes place internally, such as promotion and transfer, and (ii) external recruitment, taking place from the external environment, such as advertisement, referrals, and other sources (Arthur, 2001). Now, the recruitment industry is implementing 'smart' ways to recruit. The HR selection takes advantage of data analysis for decision making process, known as Artificial Intelligence (AI). According to Encyclopedia Britannica (2020), AI is "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings" (and intelligent beings are those that can adapt to changing circumstances). The use of AI and machine learning for HR selection, significantly reduces the time and cost for both companies and candidates. According to Geetha and BhanuSree Reddy (2018), AI can be used by HR in 8 ways while recruiting: (a) screening candidates, (b) candidate engagement, (c) re-engagement, (d) post-offer acceptance, (e) new hire on-boarding, (f) career development, (g) employee relations, and (h) scheduling. The two researchers studied how AI influences the recruitment strategy and the AI techniques used by companies for recruitment. It should be pointed out that AI is slowly adopted in this field since it is needed to overcome major barriers, such as talent gap, concern over privacy, ongoing maintenance, integration capabilities, and limited proven applications (Ernst and Young, 2018). Most of the organizations are not implementing AI because of the high cost but soon they will start to implement it, as Matsa and Gullamajji (2019) claim.

Social media could also be utilized in a HR selection process. Buettner and Timm (2018) proposed an innovative consulting approach for human resource recruitment based on an automated assessment of the fit between an employee's personality and the organizational environment. The applicant's personality traits are automatically derived from social media usage. This fit substantially influences job performance, job satisfaction, organizational commitment, and employee turnover (Verquer et al., 2003). The fit can be broken down into sub-fits, i.e. person-organization, person-group, and person-job, which together cover the entire notion of the candidate-organization environment fit. In another work, Menon and Rahulnath (2016) proposed a system that estimates the emotional intelligence of the applicants

through social media data. The proposed system processes the technical eligibility criteria based on the entries made by the users in their online resumes and the applicants' emotional aptitude by leveraging their presence in the social media. HR professionals use social networking sites (SNSs) frequently in the United States during the recruitment and selection process and before the job interview. SNSs were especially used after receiving a resume and the information gathered was perceived as reliable and valuable. When using SNSs during the application process, there is a chance HR professionals' impressions of job applicants change because of this new information. For example, photos or demographical details appeared to have a strong influence on the quality of impressions formed by one another. In short time, checking social media profiles may be useful for an organization but in long term checking SNSs can induce negative consequences for its reputation. For HR to overlook social media today would be like ignoring e-mail 20 years ago (Van den Hoogen, 2012). The sites used to research interviewers prior to attending a job interview are LinkedIn (79.6%), Facebook (15.8%), and Twitter (10.8%). Hiring managers trust the information taken from social media, while only 19.7% would not consider information gathering from social media as useful. An approach for evaluating job applicants in online recruitment systems, using machine learning algorithms to solve the candidate ranking problem and performing semantic matching techniques, was proposed by Faliagka et al. (2012). The system described in their work attempts to solve the candidate ranking problem by applying a set of supervised learning algorithms for automated e-recruitment. Applicant evaluation is based on a predefined set of objective criteria which are directly extracted from the applicant's LinkedIn profile.

Considerable work has been performed, so far, to create decision trees from data. Wahl and Sheppard (2010) compared five different approaches to extracting decision trees from diagnostic Bayesian networks. Historically, creating decision trees was based on a static set of data. The assumption was that the data set represents the underlying distribution of the data. This requires an infinitely large data set. However, by using diagnostic Bayesian networks directly, it is possible to use the distributions and the information provided by the network to create a decision tree directly. According to Wahl and Sheppard (2010), another potential method for creating decision trees from probabilistic networks is based upon using the structure of the network. Much of the previous work in creating decision trees and test selection from Bayesian networks focuses on reducing the expected cost of performing a series of actions, both tests and repairs (Mussi, 2004).

METHODOLOGY

In this work, the main target was to uncover the most influential factors in a work environment that most affect Job Satisfaction and the attrition of an employee according to the HR dataset created by IBM data scientists. The IBM HR Attrition Case Study (2020) is a fictional dataset, which aims to the identification of important factors that might be influential in determining which employee might leave the firm and who may not. As we can see in the structure of the dataset, it contains 1470 records of 31 employee properties, some job and performance related information (such as job role, job level, and performance rating), and some demographic information (such as age and education field). Moreover, some of the employee properties are factors (qualitative: 16 vars.) and the others are numerical (quantitative: 15 vars.).

The main challenge was to find a proper way to correlate to each other all the variables, independently of the fact that half of them are numerical and the rest factors. The solution of the multiple regression is not appropriate because they are not all numerical and even in the case we transform all the factors into "pseudo-numerical" this is not acceptable because there are many factors having more than two levels.

On the other hand, the assumption of linearity and normality is obviously not implemented. Facing this situation, the way that we preferred to analyze the dataset and find the right answers to the questions proposed was a series of machine learning models: first of all, an easy choice and suited for a mixed dataset with categorical and numerical variables is Decision Trees (DT).

The main problem is that the DT method works well when we have all the variables binary. The categorical variables with more than 2 levels must be divided into two levels and the numerical variables into two ranges. Because there is always the possibility that DT will not give us satisfying results, we decide to continue with Structural Equation Modeling (SEM), following with Bayesian Networks (BN). The reasons to select these methods were two: first, to validate through the regressions of SEM the validity of the nodes and finding the causality paths and second, to certify with BN that the extracted model of SEM is the right one.

With the BN implementation we take another advantage in our research: the ability to view all the possible paths of the dependent variable and finding with the conditional probabilities all the possible and best cases. This flexibility could only give BN where is obvious which variables in the network have crucial position and which are the last nodes.

The Decision Trees Approach

As we see in Table 1, the decision trees approach cannot predict over 28% and this implies that this approach is not appropriate when we have such low correlations between the variables.

Table 1 Decision Trees prediction

	1	2	3	4
1	9	6	42	28
2	13	5	34	42
3	17	8	47	56
4	10	4	59	61

Table 2 Random Forest prediction

Mtry	Accuracy	Kappa
2	0.277767	-0.044536
20	0.275917	-0.025420
38	0.271063	-0.030343

Even using the Random Forest method, we cannot obtain more than 27% of accuracy and there is a totally disagreement with negative kappa (Table 2).

The Structural Equation Modeling Solution

As we mentioned earlier, the need to use SEM was the ability to take in consideration the possible regression of all the variables taken part in the SEM network, but before implementing this we need a valid method of selecting the accepted connection through the nodes of the variables and we preferred for that to use the simple Correlation table and the Bayesian Correlation table in association with ANOVA, when we have a factor variable with more than two levels. Starting from these variables that have p-values less than 0.05, we implemented an initial SEM network, but many connections had to be erased because in the table of regressions the values were not accepted as more than 0.05 (Figure 1). Moreover, we can see that our model is overestimated because we have 66 and 87 degrees of freedom in the test model.

The Bayesian Network Solution

As we can see in the BN (Figure 2), the total variables (or nodes) involved are 21, while in SEM were 18. In SEM there were not present "BusinessTravel", "TrainingTimeLastYear", and "EducationField". All these in the BN are last nodes. The resulting network path of BN is much larger than the SEM network and it is possible to connect many variables to each other, also finding the conditional probabilities of these nodes. With SEM, we found the paths of causality of the nodes, following with the BN where we can find the best paths according to the produced conditional probabilities. In this way, a ranking table with all the possible scores of the conditional probabilities is made. In Table 3, there are 5 examples of such scores.

Figure 1 The SEM Approach

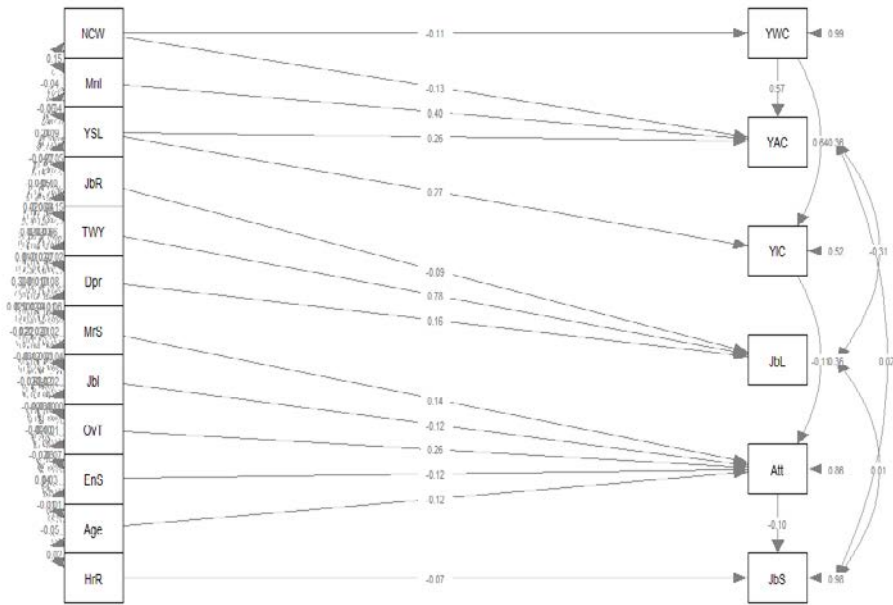


Figure 2 The Bayesian Network

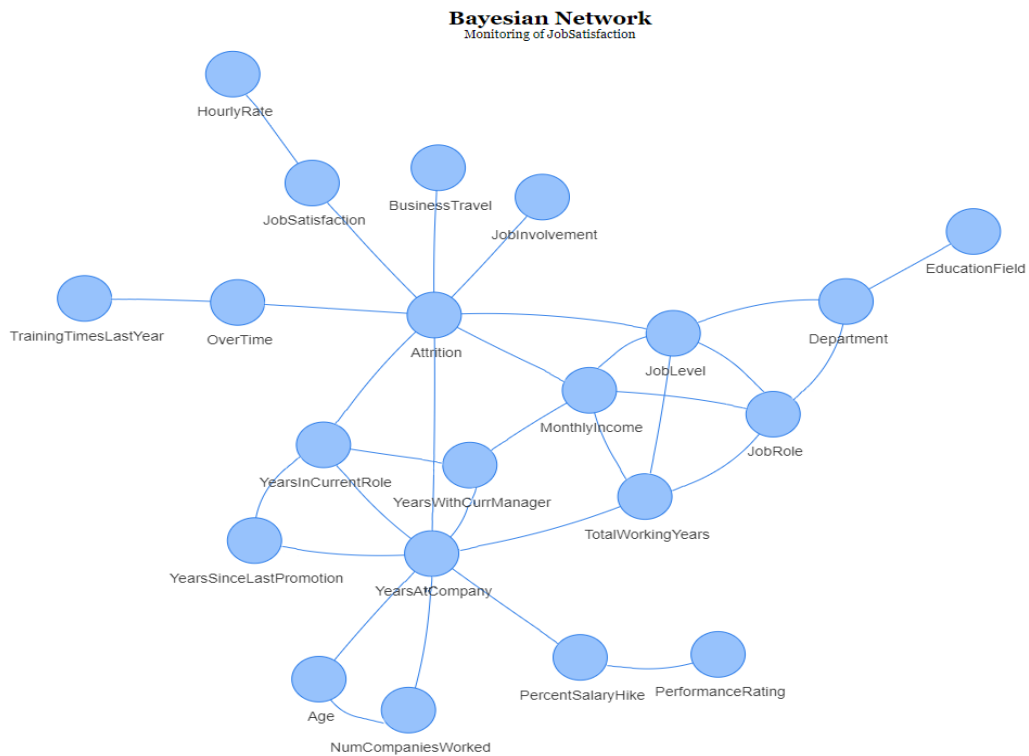


Table 3 Best paths examples

Path of nodes (with means given)	Final prob. score
JobSat.>=3 &Attr.=0 (MonthlyIncome >= 5000) & (JobLevel < 3) & (JobRole>=6)	0.3526
JobSat.>=2 &Attr.=0 (MonthlyIncome >= 5000) & (JobLevel < 3) & (JobRole>=6)	0.6539
JobSat.>=3 &Attr.=0 (MonthlyIncome >= 5000)	0.3722
JobSat.>=3 &MonthlyIncome >= 5000 Attr.=0	0.2745

CONCLUSIONS

In this work, we dealt with the problem of having a big dataset involved with HR properties having low correlation between the variables. The second problem was that there were half of them as factors and half as numeric. To find the best path of the queries about Job Satisfaction, we first used Decision Trees and Random Forest, but both showed that it is not possible to achieve more than 32% of accuracy. Then, we applied Structural Equation Modeling to obtain a first network of the model and the causality paths and consequently Bayesian Networks that gave us a more complete and flexible network of the model with the capacity of finding any conditional probability between the nodes and the respective ranking table. Finally, the factors that affect job satisfaction of an employee, are the monthly income, the job level, the job role, as well as the attrition.

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Comparison of linear regression and neural network models to estimate the actual duration of Greek highway projects

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Abstract

The aim of this study is to highlight and evaluate parameters that correlate with the actual project duration and compare performance of linear regression with neural network models to predict a reliable final duration for highway construction projects based on data available at the bidding stage. The thirty-seven highway projects that are examined, constructed in Greece, are similar in available data like the extent, the type of work packages and the significance. Considering each project's characteristics and the actual construction duration, correlation analysis is implemented, with the aid of SPSS 25. Correlation analysis identified the most significant project variables. These include archeological findings, type of terrain, land expropriation, the existence of bridge, tunnel and embankment. Furthermore, the WEKA application, through its attribute selection function, highlighted the most efficient subset of variables, both within the initial available attributes but also within the set of attributes identified through correlation analysis. These selected variables through correlation analysis and / or WEKA and appropriate combinations of these are used as input data for linear regression models and neural network models. The corresponding models (linear regression and neural networks) are presented along with their performance. Finally, this paper presents the comparison of linear regression and neural network models to estimate the actual duration of Greek highway projects. Results' discussion and conclusions along with limitations and further research are appropriately analyzed.

KEYWORDS

Highway Construction, Linear Regression, Neural Networks, Predicting Models, Project Actual Duration.

INTRODUCTION AND BACKGROUND

Kim et al. (2011), cited in Tsaousoglou et al. (2013) suggest that construction industry plays an important role in leading the national economy and macroeconomic fluctuations substantially influence the construction business. It is therefore essential for each country to promote the implementation of public infrastructure construction projects. During project implementation it is common that variations occur among the initial planning and the actual ongoing project. Variation in project costs usually results in exceeding the initial estimated cost (Aretoulis et al. 2006). At the same time projects suffer from increase in their duration. In this context, it is useful to keep in mind that each highway project is different to another one as there are a lot of parameters which play a role in the differentiation of projects. Research suggests that project location is one of the major differences in construction of highway projects. The unique legal framework in each country influences project implementation, and project procurement systems and contract types (Antoniou et al., 2014). Furthermore, construction projects are influenced by many parameters which alter the cost and schedule planning, both internal and external.

Furthermore, Glymis et al. (2017) based on FANN Tool proposed three, selected, neural network models for the prediction of actual project duration for highways, based on tender budget, length of highway project, number of lanes, number of technical projects, number of bridges, tunnels and road total length. A further research approach focused on highway project duration. The latter is estimated on the basis of variables which were known at the planning phase, and included planned cost, project type and contract type (Irfan et al., 2011). Moreover, Aziz et al. (2007) produced an approach, based on statistical regression analysis. The proposed approach predicts the cost and time of a project and, also, facilitates evaluation of the project's performance during construction. The current study includes, three methods of analysis: ridge regression analysis, general regression analysis and non-linear partial leastsquare regression analysis. More specifically, data collected from completed projects included the type of pavement, contract value, duration and project miles. Jiang and Wu (2007), considered 1818 projects from the area of Indiana. Their research identified factors which affect directly the duration and the cost of each project. These critical factors include type of the project, production rates of the construction firm, location of the project and weather condition. appeared. Anastasopoulos et al. (2012), used data from 1,722 projects from Indiana. His research identified critical parameters for consideration in models. The variables which were chosen as influential included: project time delay, project cost, project type, weather,

level of competition, difference between the winning bid amount and the engineer's estimate and finally difference between the winning bid amount and the next lowest bid.

Pewdum et al. (2009) analyzed highway construction project data. Their research factors affecting project final budget and duration before developing the forecasting models. They employed Artificial Neural Network (ANN). The forecasting results obtained from the proposed method were compared with those obtained from models based on earned value. In a similar context, Hola and Schabowicz (2010) produced a neural network based model to predict productivity for selected sets of machines and to calculate the task execution time and cost. Aretoulis (2019) examined selected public Greek highway projects in order to produce models to predict their actual construction cost based on data available at the bidding stage. Twenty highway projects, constructed in Greece, with similar type of available data were examined. Considering each project's attributes and the actual cost, correlation analysis is implemented, with the aid of SPSS. The optimum neural network model produced a mean squared error with a value of 7.68544E-05 and was based on budgeted cost, lowest awarding bid, technical work cost and electromechanical work cost.

The aim of this study is to highlight and evaluate parameters that correlate with the actual project duration and compare linear regression with neural network models to predict a reliable final duration for highway construction projects based on data available at the bidding stage.

The current research approach also aims at considering special characteristics of projects, realized in Greece. These include archeological findings, type of terrain and land expropriation. Considering each project's characteristic and the actual construction duration, correlation analysis is implemented, with the aid of SPSS 25. This paper presents the results of a relevant literature review on construction project duration, and the recorded corresponding findings, with emphasis on the parameters that have been identified. Furthermore, the WEKA application, through its attribute selection function, highlighted the most efficient subset of variables, both within the initial available attributes but also within the set of attributes identified through correlation analysis. These selected variables through correlation analysis and / or WEKA and appropriate combinations of these are used as input data for linear regression models and neural network models. The corresponding models (linear regression and neural networks) are presented along with their performance. Finally, this paper presents the comparison of linear regression and neural network models to estimate the actual duration of Greek highway projects. Results' discussion and conclusions along with limitations and further research are appropriately analyzed.

METHODOLOGICAL APPROACH

The present study is aimed at the production of reliable and efficient models (linear regression and neural networks) for the prediction of actual construction duration of highway projects in Greece. The sample projects under examination include 37 highway projects of similar extent and content (Titirla and Aretoulis, 2019). For these specific projects it became possible to record detailed amount of the same type of data, both quantitative and qualitative. The methodology steps included the following:

Step 1: Consideration of 37 selected highway projects and collection of corresponding data.

Step 2: Construction of an appropriate SPSS database, including both quantitative and qualitative variables.

Step 3: Descriptive statistics of the sample projects' variables.

Step 4: Correlation statistical analysis among the available variables and actual project duration. Analysis was conducted one time for quantitative variables and a second time for mixed variables, both quantitative and qualitative variables.

Step 5: Creation of a ranked list of variables, based on a decreasing degree of correlation coefficients.

Step 6: Proposal of Linear Regression (LR) and Neural Network (NN) models. The models were created starting with the highest correlating variable and then adding one more variable each time from the ordered list based on correlation degree (correlation coefficient) (Step 5).

Step 7: Comparison of the produced LR and NN models.

Database description

The sample projects under examination include 37 highway projects of similar extent and content. The database included data from 36 Egnatia Odos' sub-projects and 1 smaller project in terms of acreage, cost, and time of completion. Egnatia Odos is one of the most modern highways in the Southeast Europe and part of the TEN-T corridors. The projects were selected on the basis of data uniformity and availability. The available variables are the followings: Project length, Initial cost, Land requirement, Landfill, Tender offer, Embankment, Initial duration, Geotechnical project, Number of lanes, Existence of Tunnel, Number of technical projects, Existence of Bridge. These variables are

characterized as quantitative and qualitative and are presented in Table 1. The quantitative variables take on numerical values, and the qualitative variables take on binary (Yes/No) or ordinal values.

Table 1. Variables of investigated projects

Variables	
Quantitative variables	Qualitative variables
Project length	Landfill
Initial duration	Geotechnical project
Initial cost	Embankment
Number of lanes	Tunnel
Number of technical projects	Bridge
Tender offer	Land requirement

Correlation analysis

An SPSS database was created to record all the available variables. The database consists of 37 cases (number of projects) and 12 variables, which cover common available data across all the projects and according to expert opinion greatly affect the project duration. These variables were recorded as quantitative and also transformed, where possible, into qualitative ones to facilitate additional statistical analyses. Six variables remained as quantitative, while the other six were transformed into qualitative. The values of the IBM SPSS Statistics database were used to identify the correlations among the independent quantitative variables and actual project duration. Furthermore, based on the findings of the correlation analysis, a number of linear regression and neural networks models were designed and implemented, to predict the actual duration of the projects. A brief look on the correlation analyses' results reveals that actual project duration is associated in descending correlation degree with the following variables: initial cost; tender offer; initial duration; embankment; number of lanes; existence of geotechnical projects; length; existence of bridges; and existence of tunnels.

MODELS

Linear regression

Linear regression is a linear approach to modeling the relationship between a scalar response (or dependent variable) and one or more explanatory variables (or independent variables). In linear regression, the relationships are modeled using linear predictor functions whose unknown model parameters are estimated from the data. Such models are called linear models. Most commonly, the conditional mean of the response given the values of the explanatory variables (or predictors) is assumed to be an affine function of those values; less commonly, the conditional median or some other quantile is used. Like all forms of regression analysis, linear regression focuses on the conditional probability distribution of the response given the values of the predictors, rather than on the joint probability distribution of all of these variables, which is the domain of multivariate analysis. Having identified the potential correlations among the selected common variables, the current paper applies the linear regression analysis. The selected method is the stepwise. The aim is to predict the final duration. After the analysis of the 37 data cases the following linear regression equations are proposed:

$$\text{Actual project duration} = 841,539 + 4,632 \cdot 10^{-6} \cdot \text{initial cost} \quad (1)$$

$$\text{Actual project duration} = 424,729 + 2,818 \cdot 10^{-6} \cdot \text{initial cost} + 0,843 \cdot \text{initial duration} \quad (2)$$

The first equation includes only one variable, the initial cost and predicts the actual project duration with a predictability of 67% , while the second one includes two variables, the initial cost and the initial duration and it is able to predict the actual project duration with higher predictability equal to 72%. The above-mentioned data are presented in the following tables, namely Table 2 and Table 3.

Table 2 Model Summary from SPSS 25

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.678 ^a	0.460	0.444	296.23948	0.460	29.788	1	35	0.000	
2	.734 ^b	0.539	0.512	277.57713	0.079	5.865	1	34	0.021	1.485

Table 3 Model Coefficients from SPSS 25

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error				Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	841.539	66.564		12.643	0.000	706.407	976.671					
	INITIAL_COST	4.632E-06	0.000	0.678	5.458	0.000	0.000	0.000	0.678	0.678	0.678	1.000	1.000
2	(Constant)	424.729	183.069		2.320	0.026	52.688	796.769					
	INITIAL_COST	2.818E-06	0.000	0.412	2.579	0.014	0.000	0.000	0.678	0.405	0.300	0.530	1.888
	INITIAL_DURATION	0.843	0.348	0.387	2.422	0.021	0.136	1.550	0.670	0.384	0.282	0.530	1.888

Neural networks

Neural networks produced several models. The dependent variable was “Actual Project Duration” in days. Twenty-one projects were used for training the neural network and sixteen projects were used for testing the produced neural network. The methodology involving the application of neural networks for the prediction of actual duration is based on multiple neural networks designed and applied specifically for the problem at hand. The current research is contributing and focusing on identifying the best possible combination of input variables for the optimum prediction. The best Neural network model has the smaller minimum squared error (MSE). The proposed model is the one that includes the top 12 variables, namely, initial cost, initial duration, length, lanes, technical projects, bridges, tunnels, geotechnical projects, embankment, landfill, land requirement and tender offer. This neural network model has a MSE equal to 1.53E-06.

CONCLUSION AND FURTHER RESEARCH

This paper presents the important variables that correlate with the actual project duration and compare linear regression with neural network models to predict a reliable final duration for highway construction projects based on data available at the bidding stage. In total, 37 highway projects constructed in Greece with similar extent and content, were investigated. The corresponding models (linear regression and neural networks) are presented along with their performance. Finally, this paper presents the comparison of linear regression and neural network models to estimate the actual duration of Greek highway projects.

The proposed model of linear regression includes only 2 variables, the initial cost and the initial duration, while for the neural networks the corresponding model includes the top 12 variables, namely, initial cost, initial duration, length, lanes, technical projects, bridges, tunnels, geotechnical projects, embankment, landfill, land requirement and tender offer.

The linear regression model is able to predict the actual project duration with a predictability of 72% while the neural network model produces a MSE equal to 1.53E-06.

A further research in this area could aim at the development and the comparison of the results with other methods and tools. In addition, a wider number of projects should be included, so that correlations and trends that are not observed by this research could be identified in a more extensive research and at the same time increase models’ reliability and accuracy.

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A Clustering and Statistical Forecasting Approach for Replenishment of Common Spare Parts in the Maritime Industry

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Abstract

This paper presents the results of research conducted on behalf of a Greek ship management company operating a sizeable fleet of commercial maritime vessels. The first objective of this study is to develop a methodological approach for the application of appropriate clustering techniques in order to identify Common Spare Parts (CSP), i.e. spare parts that are common in more than one vessel. The successful implementation of the clustering process led to the elaboration of the CSP dataset including all available information on the items' characteristics and order history. This is a critical step for the success of the proposed approach, since including accurate data in the initial dataset is considered essential for the efficiency of both the purchasing and fleet maintenance processes. Next, this study proposes an approach based on a pair of statistical forecasting manipulations on the available data leading to reduced forecast error, lower inventory carrying costs and eventually reduced cost of purchasing and replenishment. The proposed approach is consisted of two components, i.e. the statistical forecasting component, which calculates the demand for CSP and the cost optimizer component, which yields a minimized total cost solution across the entire supply chain. The application of the proposed clustering and forecasting approach in the case company, produced ambitious results leading to a reduction of the total replenishment cost of 16,4%.

KEYWORDS

maritime logistics, replenishment, common spare parts, clustering, machine learning, forecast error.

INTRODUCTION

Spare parts are a fundamental resource used for the ship maintenance strategy to be implemented successfully. Maritime assets can be considered as a collection of technical systems having multi-indenture structures (Eruguz et al., 2018). The maintenance of the machinery onboard a vessel is a critical task, since any engine failure results in delays and down-times in the voyage of a vessel, further translated into additional cost and penalties (Kian, Bektas, & Ouelhadj, 2019). Therefore, the successful maintenance of the fleet consists a crucial financial factor for the ship management companies, regarding both the cost of spare parts' acquisition and the cost that derives from the shortage of necessary spare parts. Apart from increasing the cost of logistics, one should not overlook the importance of efficient spare part management in the prevention of inventory shortage related supply chain management crises, since the operations-based nature of the shipping industry deems it prone to inherent supply risks as a results of outsourcing supply practices (Ponis and Ntalla, 2016).

Maintenance procedures can be separated into planned and unplanned. This paper focuses on the unplanned maintenance needs of a fleet. Several spare parts can be considered essential for the efficient operation of the vessels and consequently the fleet of a ship management company. For achieving the aforementioned objectives, maintenance activities are costly and according to literature they can contribute in the range of 25–35% to the operating costs of a maritime asset (Turan, 2009), while unexpected downtimes occurring from failure of equipment can lead to a significant loss of revenue. Actually, in the event of failure, the cost for the immediate replenishment (spot order) of those parts, is higher than that of a routine replenishment. Therefore, it would be beneficial for ship management companies to keep in stock those parts, in order to avoid the cost overheads. However, the needs that derive from each specific vessel are not sufficient to financially justify the stock keeping strategy.

This paper determines specific Common Spare Parts (CSP), which are parts compatible with a number of the fleet's vessels, in order to support the creation of spare parts stock and reduce the overall replenishment cost. In order to do that, clustering algorithms were used to determine the CSP of high interest. After the detection of the specific codes of interest, their demand is forecasted using an array of methods and finally the replenishment strategy is optimized based on the minimization of the total cost function which includes the acquisition cost, the logistics/forwarding cost, the cost of the installation and the inventory cost. Some of the challenges posed by the aforementioned procedure are:

- The volume of information: The original dataset consists of more than 19,000 spare part codes from which the analysis attempts to pinpoint specific common spares of interest. This poses several challenges as described by (Acharjya & Kauser, 2016).
- The uncertainty: Spare parts demand forecasting poses several difficulties as the demand is lumpy, intermittent (Hemeimat, Al-Qatawneh, Arafeh, & Masoud, 2016) and can arise at any time (Jiang, Kong, & Liu, 2011).
- Inventory management: When dealing with erratic demand patterns, the inventory management and replenishment strategy become increasingly difficult (Fotopoulos & Wang, 1988).

THE CLUSTERING COMPONENT

The original dataset comprised of more than 19,000 possible CSP. That amount of information is difficult to handle and pinpoint the CSP of high interest and therefore clustering algorithms were used. Clustering is one of the most common unsupervised machine learning techniques (Hinton & Sejnowski, 1999). Identifying the input variables in the unsupervised learning algorithm is of great importance as the relationship between them will determine the product codes upon which forecasting will be attempted. In this study, we identify the following input variables, a) Number of Vessels: which indicates the compatible vessels for each spare part, parts with less than 3 compatible vessels are excluded from the analysis, b) Average number of orders per Year: which indicates the annual amount purchased for each code during the previous years, c) Spot Ratio: which indicates the percentage of high priority orders for each code and therefore consists the main factor for calculating each code's necessity for the fleet, codes with Spot Ratio 0% are excluded as this is the main factor that drives the overhead cost of an order, d) Percentage of orders not in Dry Dock: Dry Dock is a procedure of planned maintenance which occurs every five years for each vessel, parts that are mainly purchased regarding Dry Dock maintenance are of no interest for the analysis, e) Weighted Lead Time: which indicates the lead time of every code considering mostly recent years, codes with Weighted Lead Time less than 15 days are excluded from the analysis as they are considered virtually delivery-ready.

Having determined the main characteristics of interest, a clustering algorithm is required, in order to identify the 'outliers' of the dataset thus labeling the items that have characteristics as described above. In this paper, the DBSCAN algorithm (Ester, Kriegel, Sander, & Xu, 1996) is used, as it automatically creates a cluster containing the outliers. Density-Based Spatial Clustering of Applications with Noise (DBSCAN) is a data clustering algorithm that given a set of points in some space, classifies in the same category, points that are closely packed together by creating regions of high density points. At the same time, it marks as outlier points, those that lie in low-density regions and therefore differ from the rest of the dataset. The items are clustered using DBSCAN algorithm with minPoints=6 and local radius for expanding cluster set to eps = 1.2. The results are visualized in Figure 1 and the mean values of the created clusters are displayed on Table 1.

Figure 1. Clustering Results (DBSCAN)

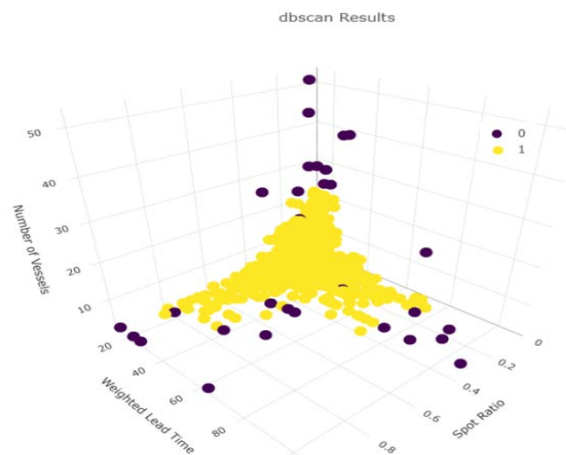


Table 1. Clustering results by mean values

cluster	Number of Vessels	Weighted Lead Time	Spot Ratio	Orders per Year	Orders not in DD	Observations
0	14,5	52,8	38%	6,6	86%	33
1	5,2	24,1	22%	2,3	76%	1456

Cluster 0 contains the outliers of the analysis. The mean values of the outliers are considerably higher than those of cluster 1 which contains the majority of the data. Therefore, the observations contained in cluster 0 can be considered as the most important CSP for the fleet operated by the company. After further analysis on each item of Cluster 0, items that cannot financially support the creation of stock are excluded. The main reasons for exclusion are: a) items purchased once for each vessel, b) zero

purchases during the last 2 years, c) few amount of total ordered quantity throughout the years. That leads to the reduction of the most important CSP to 14 specific codes.

THE DEMAND FORECASTING COMPONENT

As the items of interest are common spare parts, two approaches can be used to forecast their demand for the following year. The Total Quantity can be forecasted using the time-series data that have been created throughout the years for each item. However, the patterns of total annual demand are lumpy, making a possible forecast difficult. The second approach consists of the forecasting for the Quantity/Vessel for each of the vessels that will demand each item. The patterns of the second approach are smoother and easier to efficiently predict, but this approach contains an additional uncertainty factor: the number of vessels that will demand the item. When the approach of the Total Quantity yields satisfactory results, it is selected in order to avoid the additional uncertainty factor.

Several methods were used for the demand forecasting of the created time-series: a) Simple Moving Average, b) Simple Exponential Smoothing, c) Croston's and its variations (Syntetos & Boylan, 2001), (Teunter, Syntetos, & Zied Babai, 2011). For each item the most efficient approach and method is chosen by calculating the Mean Absolute Percentage Error for the last 3 years' forecasts as per below formula:

$$MAPE = \frac{|forecast - actual|}{actual}$$

The various methods led to forecasts with less than 14% MAPE on average. The Normalized Forecast Metric (NFM) was also computed and used for the proper rounding of the forecast results.

$$NFM = \frac{Demand - Forecast}{Demand + Forecast}$$

COST OPTIMIZATION COMPONENT

The optimum replenishment strategy lies in determining the optimum service level regarding the Safety Stock which follows the formula bellow (Fotopoulos & Wang, 1988):

$$Safety\ Stock = Z_{SL} \cdot \sqrt{LT \cdot (\sigma_{demand})^2 + \overline{Demand}^2 \cdot (\sigma_{LT})^2}$$

where LT is the lead time, Z_{SL} is the inverse distribution function of a standard normal distribution with cumulative probability of the underlying service level and demand refers to the historical demand of the relevant item. Two cost factors should be calculated in order to determine the optimum service level:

$$Inventory\ related\ cost = Acquisition + Transportation + Storage + Cost\ of\ Capital$$

$$Stock - out\ cost = SR \cdot (Acquisition + Transportation + Administrative)_{Spot} + (1 - SR) \cdot (Acquisition + Transportation + Administrative)_{Routine}$$

where SR stands for Spot Ratio. Spot orders are the main factor that leads to the increase of the total replenishment cost. The connection between the above cost functions stems from the Service Level (SL), as the probability of stock-out is 1-SL, therefore the optimum SL can be calculated as the one that minimizes the summary of the aforementioned costs. The optimum reorder point is also calculated to complete the proposed replenishment strategy (Fotopoulos & Wang, 1988):

$$ROP = \overline{LT} \cdot \overline{Demand} + Safety\ Stock$$

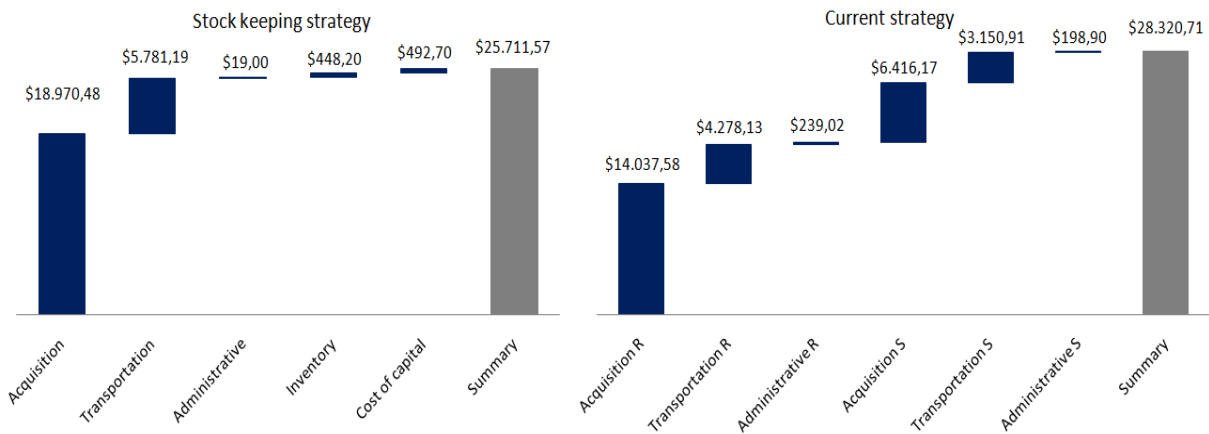
The total cost of ownership (TCO) that derives from the stock keeping strategy that is examined and the current strategy that the company is applying are calculated by the following formulas:

$$TCO_{stock\ keeping} = Acquisition + Transportation + Administrative + Inventory\ cost + Cost\ of\ Capital$$

$$TCO_{current} = SR \cdot (Acquisition + Transportation + Administrative)_{Spot} + (1 - SR) \cdot (Acquisition + Transportation + Administrative)_{Routine}$$

Regarding the stock keeping strategy, the administrative cost is calculated one time as the order is placed once for the annual quantity. The cost of the current strategy derives from the summary of replenishment costs for Routine and Spot orders respectively. The TCO for the two strategies are displayed on Figure 2 for the annual forecasted quantity of a specific common spare.

Figure 2. Comparison of the total cost of the two strategies



Symbols R and S refer to Routine and Spot costs respectively. The optimization of the replenishment strategy for the 14 CSP, led to the reduction of the total replenishment cost by 16.5% for the purchasing department of the ship management company.

CONCLUSIONS

The main objective of this paper is to propose a methodological approach utilizing the power of clustering and statistical forecasting techniques, which can be used by the purchasing departments of companies managing and operating a fleet of vessels in the shipping industry. The approach consists of three discrete methodological steps. In the first step common spare parts of high interest for the company's fleet are detected using clustering algorithms. In the next step a comprehensive forecasting procedure is developed in order to forecast the quantities for the next year. Finally, in the third methodological step, a cost-related decision support tool is developed proposing the optimum replenishment strategy which minimizes the total replenishment cost.

This paper's analysis, led to the detection of 14 common spare parts of interest in the fleet of a ship management company. Their demand was forecasted for the following year using an array of methods and an optimum replenishment strategy was developed based on the minimization of the objective cost function which includes the cost components involved in the replenishment procedure. The application of the strategy led to an estimated 16.5% reduction in the total replenishment cost for those specific items. The application of our proposed approach produced several interesting findings that can fuel fruitful discussions at the decision-making level of the companies in the shipping industry. The value of clustering algorithms cannot be overlooked as the application of such methods can easily pinpoint items of interest in the vast amount of information and the countless product codes that a company deals with. As occurred from the forecasting procedure, the application of various methods and approaches can lead to promising forecasting results. The total reduction of the replenishment cost depends on the company's purchasing procedures and cost factors. Lastly, the model that was developed can be implemented by various companies in several industries that manage a fleet of vessels, aircrafts or vehicles but also by petrochemical companies and government institutions like the military.

Opportunities for future research include the implementation of additional forecasting methods like (Holt, 2004), (Winters, 1960), (Gardner & McKenzie, 1985) as the amount of information increases, in order to further reduce the MAPE. Lastly, the detection of additional common spare parts of high interest can be achieved by better guiding the clustering algorithms and increasing the dimensions of the clustering procedure.

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Session 15: Simulation

chair: Georgios Koulinas

Simulation models for improving order picking via different class-based storage policies and material handling equipment: The case of a multinational food and beverage company

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Abstract

It is widely common that order picking is one of the key processes in a storage facility. The latter incorporates the finding and extracting of products from a storage location in order to fulfill customer orders. In practice, picking process can be complex since a series of parameters must be taken into consideration such as material handling equipment, routing policies (e.g. S-shape/traversal, return, combined, optimal), picking policies (e.g. discrete, batch, zone picking) and so forth. Therefore, order picking is considered to be the most labor-intensive and expensive activity for a warehouse. Thus, the need for overall picking improvement drives companies to identify innovative methods and techniques to improve picking efficiency and accuracy and the same time minimize operational cost. In this paper, we investigate the use of electric pallet trucks and various storage class-based scenarios in order minimize order picking time for order fulfilment in a multinational food and beverage company. Initially, we represent the current operation of order picking by using an appropriate simulation model. The latter includes the use of back-to-back racks and S-shape/traversal routing policy for discrete picking. Subsequently, we present five what-if scenarios using simulation modelling: (a) comparison of manual vs. electric pallet truck using S-shape routing policy for discrete picking, (b) use of a combination of electric pallet truck and four different class-based product storage policies vs. no storage policy (S-shape/traversal routing policy for discrete picking is applied in all four scenarios as well). The results obtained are encouraging showing a reduction of total order picking time that varies between 9% and 12%.

KEYWORDS

Back-to-back racks, electric pallet truck, class-based product storage, simulation models

INTRODUCTION

Warehouses are an important part of every supply chain. Due to the increase of e-commerce as well the need for smaller and frequent order fulfilment, storage processes should be flexible, agile, and cost-effective (Bartholdi & Hackman, 2019). To this end, companies are always seeking to adopt information systems, automation, and logistics techniques so as to handle processes such as receiving, put-away, picking, packing, and dispatching of products, in an optimal manner. Order picking is one of the key processes in warehouses (Christopher, 2016; Bartholdi & Hackman, 2019). It includes the process of retrieving products from the storage locations in order to prepare a customer's order. It is considered to be the most labor-intensive and costly activity in a warehouse facility (Žulj et al., 2018). On the grounds that the process of order picking, most of the times is done manually, warehouse managers consider order picking as the highest-priority activity for productivity improvements (De Koster et al, 2007). Thus, the need for overall picking improvement, drives companies to seek for innovative methods and techniques in order to improve picking efficiency and accuracy (Bartholdi & Hackman, 2019). A way to investigate whether alternative picking methods are able to improve the order picking process is via simulation modelling. The latter allows the testing of different scenarios in order to find the best solution that minimizes picking time (Bahrami et al., 2017). Moreover, by using simulation, many alternative solutions can be tested quickly and easily, with little risk and without influence on existing processes (Banks et al., 2010).

To this end, the aim of this paper is to present results from simulation models developed in order to improve order picking via different class-based storage policies and material handling equipment in a multinational food and beverage company. Initially a simulation model that shows the existing execution (AS- IS scenario) of the picking process is presented. The AS-IS model, incorporates back-to-back racks and S- shape/traversal routing policy using manual pallet truck. Then we present five what-if scenarios (TO-BE scenarios) where different class-based product storage policies are

tested. Furthermore, an electric pallet truck is used in order to investigate the impact of material handling equipment in order picking. The remainder of this paper is organized as follows. Section two presents a literature review on order picking operations using simulation. Section 3 describes the current operation of order picking process of a company under study. The proposed models (TO-BE models) for alternative ways of executing order picking are presented in Section 4. The results and conclusion of this paper are presented in Section 5.

LITERATURE REVIEW

Order picking has been the topic of much research over the past decades. Many authors (Rouwenhorst et al, 2000, De Koster et al 2007, Chackelson et al, 2013) argue that various parameters should be taken into consideration when an order picking process is organized such as routing policies (e.g. S-shape/traversal, return, combined, optimal), picking policies (e.g. discrete picking, batch, zone picking), storage policies (random, dedicated, class-based, family grouping), picking technology (Pick by scanner, Pick by light, Pick by vision, Pick by voice), and type of picking (goods to picker, order to goods).

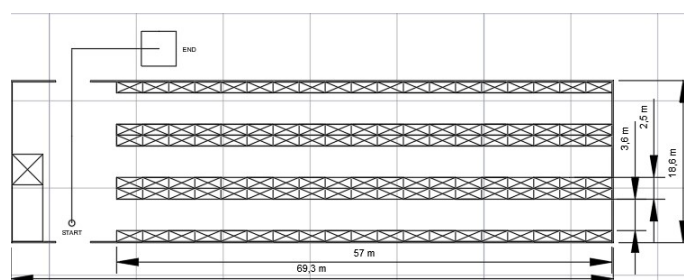
In this paper we focus mainly on proposing alternative order picking models by taking into consideration routing, picking, and storage policies. Routing policies determine the route of picker in a warehouse in order to collect all products which are mentioned in their picking list. In this paper we will examine the S- shape/traversal policy, where a picker enters to the aisle from one end and leaves from the other. Picking policies determine which products (SKUs) are placed on a picking list and subsequently retrieved from their storage locations by a single picker (Petersen & Aese, 2003). Usually, three picking policies are considered: discrete picking, batch, and zone picking). In this paper we will consider the use of discrete order picking. The latter is one of the most common policies that is adopted in a warehouse. A picker completes a tour through the all aisles of warehouse in order to pick all the SKUs which are mentioned in a single order. It is worth mentioning that this policy is often preferred because it is easily implemented and order integrity is always maintained (Gibson and Sharp, 1992; Petersen, 2000; De Koster et al., 1999). Finally, storage policies determine how SKUs are inserted into storage locations. There are several types of storage assignments such as random storage, closest open locations storage, dedicated storage, class-based storage, and so forth (Rouwenhorst et al, 2000, De Koster et al 2007, Chackelson et al, 2013). In this paper we consider the use of class-based storage (ABC). In a class – based storage the SKUs are placed in a way so as the fast-moving products to be close to the dispatching area (usually in the first bays of each aisle). These SKUs are called A – items followed by B – Items which are about 30% of all SKUs and contribute about 15% of the workload. Finally, C –items contain about 50% of all SKUs and contributes about 5% of the workload (De Koster, et al., 2007).

In the following section we present the current operation of a warehouse (in terms of picking process) and we show the development of a simulation model that represents the current order picking process.

DESCRIPTION OF CURRENT ORDER PICKING OPERATION

The case under investigation deals with the order picking process of fast-moving consumer goods (FMCGs) that are produced by a multinational food and beverage company which is active in over 200 countries. The latter has assigned the storage and distribution operations in Greece, in a third-part logistics operator (3PL), namely SYNERGY SA, which operates multiple distribution centers to manage the delivery of its depositors' products to the end customers. Figure 1 depicts the layout of the warehouse area where the order picking of products of the company under investigation takes place. It consists of 6 Back-to-Back racks. Every rack embraces 6 levels for storage and 19 bays. Each bay has 3 slots for storage and picking of products. The level from which the picking process takes place is the zero level. It is worth mentioning that, 103 different SKUs are managed during the picking process.

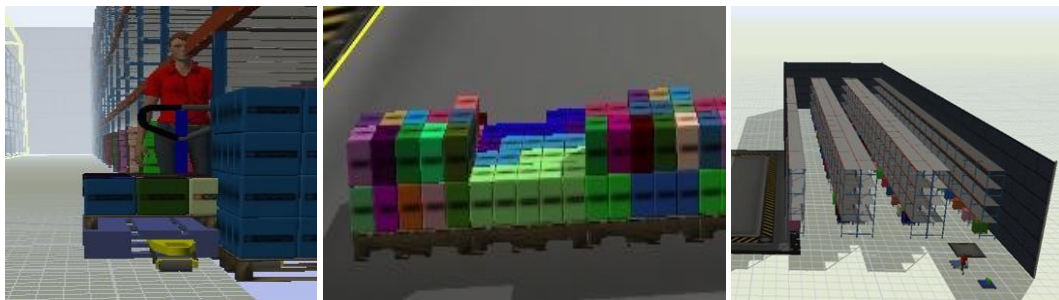
Figure 1. Layout of warehouse area where the storage and picking process takes place



During the process of order picking, a euro pallet is used by each picker as well as a manual pallet truck for collecting the orders. Level 0 is the location where the order picking procedure takes place. Each picker begins to collect the SKUs from the start point as shown in Figure 1. The routing policy adopted by the picker is the S-type/traversal and the picking policy is discrete picking. When the picker collects all products of a single picking list, they place the pallet in the end point which is a provisional storage area. The latter is depicted also in Figure 1.

The primary data received from the 3PL company included 103 SKUs as mentioned previously. These SKUs existed in 60.387 order lines. All orders were counted to 4.848. In our simulation model, in order to complete the entire workload, we used one picker. It took 2.953.777 seconds (approximately 820 hours) for the whole picking process to be completed. For building the simulation model in order to represent the current order picking operation we used the Flexsim software tool. The latter is a discrete picking software for modeling, analyzing, visualizing, and optimizing any process which we want to simulate. It also gives us the opportunity to design our warehouse modeling using items of its library. In order to build the model, we took into consideration the current warehouse layout where 6 Back-to-Back racks are used for storing the products of the company under investigation. We used one operator with a manual pallet truck to complete all the workload. Snapshots of the simulation model developed are shown in Figure 2. After running the simulation model, the total picking time was equal to 2.953.771 seconds. When comparing the time the picker needed to complete the workload on the developed simulation model versus the real order picking time, there was a difference of 6 seconds thus we could assume that the simulation model represented in high detail the current order picking operation.

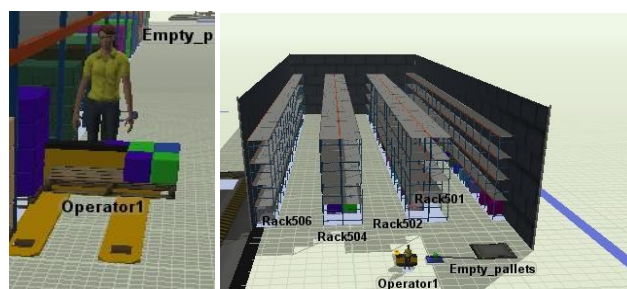
Figure 2. Warehouse layout representation of the AS-IS model in Flexsim software



PROPOSED MODELS (TO-BE MODELS) FOR EXECUTING ORDER PICKING

In this section we present the proposed order picking methods (TO-BE) and we compare them with the current order picking operations in terms of order picking efficiency (i.e. time to complete the picking workload). Our objective is twofold. First, we investigate the impact from the use of an electric pallet truck and then we examine how class-based storage in combination with the electric pallet truck affects order picking performance. In the proposed simulation models, we use the same primary data received from the 3PL company. The first proposed model (TO-BE 1) engages the use of an electric pallet truck instead of the manual pallet truck used in the current operation (Figure 3). The picker is using again the S-shape routing policy and collects a single order per time (i.e. discrete picking). The picker follows the same route as in the current operation in order to collect all the appropriate products which are included in the picking lists. The speed of the electric pallet truck is 6 km/h. After running the simulation model, we observed a reduction of order picking time that was equal to 260.741 seconds. This time is actually 8.83% better than the current order picking time. Thus, we may conclude that the use of an electric pallet gives a great increase in productivity. As far as the cost of acquiring an electric pallet truck, we calculated that the return-on- investment is less than a year.

Figure 3. Warehouse layout representation of the TO-BE 1 model in Flexsim software



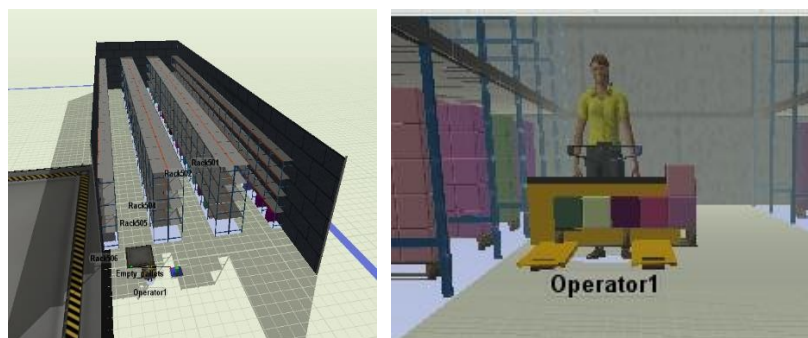
In order to build the TO-BE 2 model we use a combination of electric pallet truck and four different class-based product storage policies vs. no storage policy (S-shape/traversal routing policy for discrete picking was applied in all four scenarios as well). Other policies could also be adopted and examined, however the scope of this paper was to focus on two specific parameters that affect picking efficiency which are: a) picking equipment and b) storage policy. As already mentioned, the SKUs were divided into 3 different types, namely A, B and C-type SKUs. A-type SKUs are presented in green color, B-type SKUs in yellow color and C-type codes with red color. From the 103 SKUs, 38 were A-type, 24 B-type and 41 C-type. We run four different what-if scenarios. The speed of electric pallet was set again at 6 km/h. The different class-based storage scenarios are shown in Figure 4.

Figure 4. Warehouse layout representations of the TO-BE 2 models in Flexsim software



Snapshots from the warehouse layout representation of the TO-BE 2 simulation models (4 what-if scenarios) are shown in Figure 5.

Figure 5. Warehouse layout representation of the TO-BE 2 model in Flexsim software



The results obtained from TO-BE 2 simulation models as well as the TO-BE 1 simulation model are presented in Table 1. Furthermore, Table 1 presents the time savings that each model obtained when compared to the AS-IS model. As it can be seen, the use of an electric pallet truck together with class-based product storage policy of the What-if Scenario

1 gives the best results (i.e. 11.83% order picking time savings).

Table 1. Results of proposed (TO-BE) models and comparative assessment with current operation (AS-IS model)

TO-BE Simulation models	Scenarios	Time savings in % (comparison with the AS-IS model)
TO-BE 1 – Electric pallet truck	N/A	8.83%
TO-BE 2 - Combination of electric pallet truck and class-based storage policies	What-if scenario 1	11.83%
	What-if scenario 2	10.86%
	What-if scenario 3	10.33%
	What-if scenario 4	9.43%

CONCLUSIONS

In this paper, we investigated the use of electric pallet trucks and various storage class-based scenarios in order to minimize order picking time for order fulfillment in a multinational food and beverage company. Initially, we represented the current operation of order picking by using an appropriate simulation model. The latter included the use of back-to-back racks and S-shape/traversal routing policy for discrete picking. Subsequently, we presented five what-if scenarios using simulation modelling: (a) comparison of manual vs. electric pallet truck using S-shape routing policy for discrete picking, (b) use of a combination of electric pallet truck and four different class-based product storage policies vs. no storage policy (S-shape/traversal routing policy for discrete picking is applied in all four scenarios as well). The results obtained are encouraging, showing a reduction of total order picking time that varies between 9% and 12%.

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Testing alternative product storage policies and warehouse equipment for order picking improvement via simulation modeling: The case of a medical supplies and health products company

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Abstract

Warehouses handle a significant amount of processes ranging from receiving, put-away, storage to replenishment, picking, packing and dispatching of products. Across the various functions in a warehouse, order picking, referred to as the operation of retrieving the required SKUs from a storage location to fulfill a customer order, represents over 50% of the overall operating cost in a storage facility. Order picking is based on a series of parameters such as routing policy (e.g. S-shape), picking policy (e.g. discrete picking), storage policy (e.g. ABC class-based), picking density as well as average order size to name a few. Inappropriate order picking may result in less worker productivity, more works stress and higher labor turnover. In this paper we investigate the use of alternative product storage policies (e.g. class-based) and warehouse equipment (e.g. electric pallet truck) in a real-life case of a medical supplies and health products company. Initially, we represent the current operation of order picking by using an appropriate simulation model. The latter includes the use of back-to-back racks, manual pallet truck and S-shape/traversal routing policy for discrete picking. Subsequently, we present five proposed what-if scenarios using simulation modelling: (a) comparison of manual vs. electric pallet truck using S-shape routing policy for discrete picking, (b) use of a combination of electric pallet truck and five different class-based product storage policies vs. no storage policy (S-shape/traversal routing policy for discrete picking is applied in all five scenarios as well). The results obtained are encouraging showing a reduction of total order picking time that varies between 16% and 20%.

KEYWORDS

Class-based storage policies, product picking, electric pallet truck, simulation modelling

INTRODUCTION

The main activities of the warehouse such as receiving, storing, collecting orders and shipping are critical for each supply chain (Gong & De Koster, 2011). Among these activities, order collection is the most expensive warehouse activity and one that requires a significant workload (Marchet et al., 2015). As storage areas provide labor-intensive services to end customers, poorly organized process of collecting orders may result in a reduction in labor productivity while having negative effects on the customer service level (Wruck et al., 2016). In addition, new market developments, such as e-commerce, globalization, and increased customer expectations, have impaired the need for processing a large number of small orders within short periods of time (Marchet et al., 2015).

Designing of logistics systems by adopting simulation modelling may support the effective optimization of warehousing in a company. Latest developments in software tools lead to research in use of computer simulation, before, during and after logistics system designing. The use of simulation in industrial practice is safe and makes it possible to verify any change which could be realized to improve the target area (e.g. warehouse operations) of a company (Bučková et al., 2019).

The aim of this paper focuses on testing alternative product storage policies and warehouse equipment for order picking improvement via simulation modeling for a medical supplies and health products company. In particular, the initial simulation model represents the existing operation of the picking area (AS-IS scenario), including back-to-back racks and manual pallet trucks for the order picking. In the second scenario (TO-BE scenario) the operation of alternative material handling equipment for collecting orders is considered. More specifically electric pallet truck is used instead of manual pallet truck. Subsequently an additional TO-BE scenario is tested where alternative class-based product storage policies are considered. The aim is to investigate the benefit in order picking time from the above proposed scenarios in relation to the existing method of collecting orders.

The remainder of the paper is structured as follows. Section 2 provides a literature review of picking processes, different transport equipment for the picking process and storage strategies. Section 3 includes imprinting of the current state of the warehouse operation (AS-IS). The alternative methods (TO-BE models) are presented in Section 4, followed by the conclusions in Section 5.

LITERATURE REVIEW

The existing research in order picking is quite extensive and various topics have been addressed by different authors. The primary focus of this paper is mainly to investigate the impact of specific parameters that affect the performance of an order picking system namely: storage policy, storage equipment, picking policy, as well as routing and sequencing policy.

Storage policies assign products to storage location. Various types of storage assignment exist currently such as random storage, closest open location storage, class-based storage and family grouping (Manzini et al. 2015; De Koster et al., 2007). In the class-based storage policy, the items are categorized into three classes – A, B, and C. Because lifts are mostly bottlenecks in the system, each class is assigned to a dedicated tier(s) in the warehouse. Each of the classes is assigned to a dedicated zone, and products are located depending on their fast movement in and out of the warehouse (Chackelson C. et al., (2013).

Warehouse solution design is determined by the nature of storage equipment (Pyza et al., 2017). The material handling equipment used in this case study is a pallet truck (AS-IS scenario) and electric pallet truck in the proposed scenarios (TO-BE scenario).

The picking policy applied is discrete order picking. In the latter, a picker collects all items necessary to fulfill a single customer order and picks no other items until the order for the customer is complete. This method of order picking is common because it is simple and reliable since a picker needs to manage only one customer order at a time (Eisenstein, 2008).

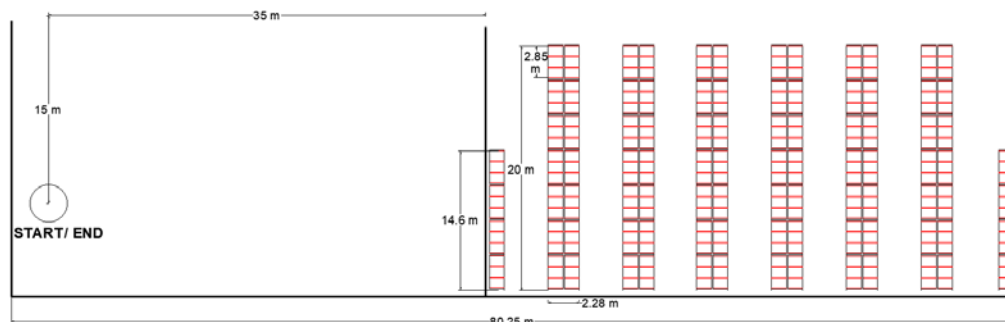
Finally, in this case study, the S-shape routing and sequencing policy is taken into consideration. With the S-shape routing policy any aisle containing at least one item is traversed through the entire length. Aisles where nothing must be picked are skipped.

The above parameters are tested in this paper by using simulation modelling. In the following sections the current operation as well as the proposed models for alternative ways of organizing order-picking are presented.

PRESENTATION OF THE EXISTING ORDER PICKING OPERATION

The products collected during the picking process belong to firm that acts in the health sector, producing and managing medical and parapharmaceutical products. This firm has assigned the storage and distribution of its products to a 3PL company. The layout of the warehouse where the products are stored is shown in Fig.1.

Figure 1 Warehouse Layout



The characteristics of the picking area of the warehouse are as follows:

- Each picking tour begins and ends at the START/END point located on the left side of the racks as shown in Figure 1.
- The demand for the SKUs is based on an 80–24 distribution so that 24 percent of the SKUs account for 80 percent of the picking activity (class-based storage).
- In the picking area pallets are stored side by side with a storage capacity of 319 SKUs
- Each SKU can be assigned to more than one storage location.
- A picker travel rate of 2.15 Km/h is assumed to be its maximum speed. The picking time includes all handling of the SKU and the necessary set-up time. These estimates are consistent with observations from various picking operations and with the literature (Petersen, 2000; Gray et al., 1992).

- Picking is completed manually with the use of one or more pallet trucks. On the pallet truck a Euro-pallet is placed as a base for the items collected.
- There are four types of item categories: sack, small size box medium box, and parcel.

To be able to simulate the existing state of the picking area, real-life primary data have been collected from the Warehouse Management System (WMS) of the 3PL operator. The picking method used is discrete picking and the routing policy is S-type as mentioned in the previous section. This existing state of the picking area serves as a baseline to which different scenarios are compared.

The discrete event simulation software used for this case study is FlexSim. This software is a typical integration between virtual reality technology and discrete object-oriented simulation. As general-purpose simulation software, FlexSim is used in a number of fields including Logistics and distribution. The models created in FlexSim for this paper represent the picking process from the ground floor and include a combination of 3D objects. The simulation model that represents the current operation of order picking is shown in Figure 2. The object number 1 as shown in the figure, represents the area where picking takes place. At the object number 2 (pallets' queue) the empty pallets are placed for the picking process whereas at the object number 3 (orders queue) the operator parks the pallet with the order (dispatching area). Finally, number 4 represents the operator. Furthermore, it is important to mention that the items to be collected are placed at the ground level (Level 0) of the racks as shown in Figure 2.

Figure 2 Representation of current order picking process in Flexsim software



The representation of the AS-IS model has been done in great success and it could be used in order to compare the AS-IS status to the proposed models for alternative picking (TO-BE scenario)

PROPOSED METHODS FOR ORDER PICKING (TO-BE scenario)

In the previous section the existing order picking methodology was presented. With the intention of improving the current status of picking, we present alternative order picking scenarios (TO BE models) by alternate the parameters described in Section 2. The first proposed model (TO BE 1) engages the use of an electric pallet truck with a maximum speed of 6 Km/h instead of the manual pallet truck used in the current operation (Figure 4). The operator uses the same picking and routing policy as in the existing order picking operation. After running the simulation model, we observed a reduction of order picking time that was up to 17% (see Table 1). Thus, the use of an electric pallet truck has a substantial increase in productivity. The second proposed model (TO BE 2), consists of an electric pallet truck and different storage policy (e.g. class-based) shown in the Figure 5 where A class items have the color green, B class items are presented with yellow color and at last the C class items are shown with red color. We created five models with different storage placement yet with the same speed of the electric pallet truck and discrete order picking. Finally, we compared the proposed picking methods with the current picking operation and the results are shown in Table 1.



Figure 4 Electric pallet truck

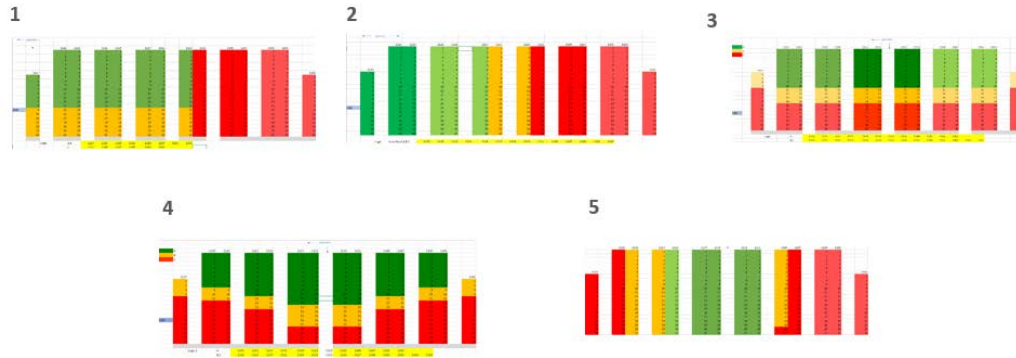


Figure 5 Class-based storage strategy (5 scenarios that were modeled and tested)

As it can be seen from Table 1, the use of pallet truck in conjunction with Class-based storage policy No.1 (i.e. What-if Scenario 1) gives the best results i.e. 19.4% less ordering picking time when compared to the current order picking method.

Table 1 Results of proposed (TO-BE) models and comparative assessment with current operation (AS-IS model)

TO-BE model	Scenario	Percentage of time saving vs AS-IS
TO-BE 1 (Use of electric pallet truck)	N/A	16.5%
TO-BE 2 (Class based storage policy & electric pallet truck)	What if Scenario 1	19.40%
	What if Scenario 2	19.14%
	What if Scenario 3	18.92%
	What if Scenario 4	18.58%
	What if Scenario 5	18.54%

CONCLUSIONS

The aim of this paper was to investigate the use of alternative warehouse equipment (e.g. electric pallet truck) and product storage policy (e.g. class based what if scenarios) in a real-life case of a medical supplies and health products company. To start with, we represented the existing picking operation of the warehouse by using an appropriate simulation model. The latter included the use of back-to-back racks, manual pallet truck and S-shape/traversal routing policy for discrete picking. Subsequently, we presented five proposed what-if scenarios using simulation modelling: (a) comparison of manual vs. electric pallet truck using S-shape routing policy for discrete picking, (b) use of a combination of electric pallet truck and five different class-based product storage policies vs. no storage policy (S-shape/traversal routing policy for discrete picking is applied in all five scenarios as well). The results obtained are encouraging showing a reduction of total order picking time that varies between 16% and 20%.

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Testing alternative warehouse storage equipment for improving order picking via simulation modeling: The case of a multinational food and beverage company

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2. Abstract

Order picking is the most labor-intensive operation in a warehouse and has a direct impact on staff productivity and operational cost. Various strategies have been proposed in the literature in order to influence the performance of order picking such as storage location assignment, routing policies, and order picking equipment. In this paper we investigate the use of alternative storage systems (i.e. live storage racks and conveyor belts) as well as a different picking policy (i.e. zone picking) in a real-life case of a multinational food and beverage company. Initially, we represent the current operation of order picking by using an appropriate simulation model. The latter includes the use of back-to-back racks and S-shape/traversal routing policy for discrete picking. Subsequently, we present two proposed what-if scenarios using simulation modelling: (a) implementation of live storage racks where the total number of SKUs are stored, and a conveyor belt used for supporting zone picking strategy, (b) a mixed solution consisting of a combination of live storage (for A-type SKUs) and back-to-back racks (for B and C-type of SKUs) where zone and S-shape/traversal routing policies are implemented respectively. The results obtained are encouraging showing a reduction of total order picking time that varies between 15% and 40%.

KEYWORDS

Simulation models, live storage racks, conveyor belt, product picking

INTRODUCTION

Warehousing is a key part of every supply chain system since it directly affects order preparation, accurate and on time delivery to final customers. To this end, the challenge for companies is to ensure a smooth flow of work, in order to avoid delays and increase productivity in warehouse activities (Bartholdi & Hackman, 2019). Although the principles of warehousing have not changed much over the years, storage solutions have developed a lot. With innovative technologies on hand, new material handling equipment, flexible storage systems and various working strategies, companies seek to increase staff productivity and minimize operational cost.

Among the typical processes of a warehouse, order picking has particular importance. It is the most labor-intensive operation that directly affects a lot of Key Performance Indicators (KPIs) and also the total level of quality of service (Fager et al., 2019). Although other warehouse operations have been automated (e.g. packing), order picking remains manual in most of warehouses. This fact pressures the order picking process as the pickers' workload becomes more and more higher and intensive (Bahrami et al., 2017). The increase of e-commerce has also been a reason for companies to start seeking for alternative methods and techniques in order to organize efficiently order picking operation.

The aim of this paper is to investigate alternative storage equipment for improving order picking via simulation modeling in a multinational food and beverage company. More specifically, we initially develop a simulation model that represents the existing operation (AS-IS scenario), which includes back-to-back racks, order picking using manual pallet truck and S-type/traversal routing policy. Then, we develop two different simulation models (TO-BE scenarios) which comprise of live storage racks, and pallet movement on conveyor belts. The zone picking method is adopted in these cases. In the first TO-BE model we store all SKUs on live storage racks. In the second TO-BE model, a mixed system of storage system is used. More specifically, the A-type SKUs are stored on live storage racks whereas B and C-type SKUs on back-to-back racks. Thus, two different picking strategies are applied. We used the FlexSim simulation software to build and run our models. Flexsim is a discrete event simulation (DES) tool that supports the processing of a significant

amount of data in short time and the comparison of the results (Roumeliotis & Souravlas, 2017). The performance of the proposed simulation models is measured in terms of total order picking time, compared to the existing one. The remainder of the paper is organized as follows. Section 2 includes a literature review on order picking operations as well as on simulation modeling in logistics operations. In section 3 the current operating status of the warehouse is represented via a simulation model (AS-IS model). The proposed order picking methods (TO-BE models) are described in Section 4. Finally, in Section 5, the paper concludes with the summary of the results.

LITERATURE REVIEW

Existing research work on order picking focuses on the study of parameters that affect the efficiency and accuracy of picking process such as the type of storage system, the order collection method, the picking technologies, and so forth. Two interesting factors that influence the amount of distance travelled by the pickers is the layout of the warehouse facility as well as the location where items are stored (Caron et al. 2000). Both factors are thoroughly investigated in various papers (Ene and Öztürk 2012; Manzini et al. 2015; Fontana and Nepomuceno 2016). In addition, the existing literature deals to a large extent with the sequence of orders as well as with the picking routing policy that is followed in a warehouse (Chen et al. 2014; Roodbergen and de Koster 2001). Furthermore, regarding the storage equipment, many authors point out the importance of using live-storage racks in combination with conveyors in terms of improving order picking time duration (Bartholdi & Hackman, 2019). Zone picking is a common picking policy which in combination to live storage racks, separates the warehouse into zones and allows pickers to retrieve SKUs from their own zone. In some other cases batching and zoning into “wave” picking is adopted where each picker is responsible for collecting SKUs in their zone for several orders. The benefits of these policies become apparent as the size of the warehouse increases. Table 1 presents the parameters used in this research, which are based on the work of Chackelson et al. (2012).

Table 1. Parameters tested in current that affect picking (Chackelson et al., 2012)

Category of parameter	Type	Description
Storage equipment	Back-to-back	The classic storage solution used in the majority of warehouse facilities.
	Live Storage	This type of rack provides efficient and ultra-dense storage of palletized goods with fewer aisles. This increases storage capacity considerably. It can also be used to avoid unnecessary internal transport.
	Hybrid	Combination of the two previous cases. Some products (A-type SKUs) are placed on live-storage racks and the rest of the products (B and C- type) on back-to-back racks.
Picking Method: Picker to goods	Discrete	In discrete order picking a picker walks to pick all the necessary items to fulfill a single customer order.
	Zone	With zone picking, SKUs are divided into separate areas, called zones. Each picker is assigned to pick from a single zone per shift.
	Hybrid	Combination of the two previous cases. Some products (A-type SKUs) are picked from live-storage racks and the rest of the products (B and C- type) from back-to-back racks. Then a consolidation of products is made since they belong to a single order
Storage Policy	Random Storage	During the put away process, products are assigned to locations that are selected arbitrarily from empty locations. Using this method, space utilization is very high, but travel distance and product identification is more time consuming. A WMS is used in such cases.
	Class-based storage	The concept of class-based storage demands that items are clustered into classes in such a way that the fastest moving class contains approximately 15% of the products stored but contributes about 80% of the turnover. Each class is assigned to a dedicated zone, and products are located arbitrarily within their area. These items are called A-type; the next fastest-moving category is known as B-type, and the rest of products as C-type. The main advantage of this strategy is the reduction of travelling time.
Routing Policy	S-Type/ Traversal	The picker moves among aisles placing goods on a pallet. Picking begins from the first aisle and proceeds through all aisles that contain picks before going to the shipping queue (i.e. dispatching area).

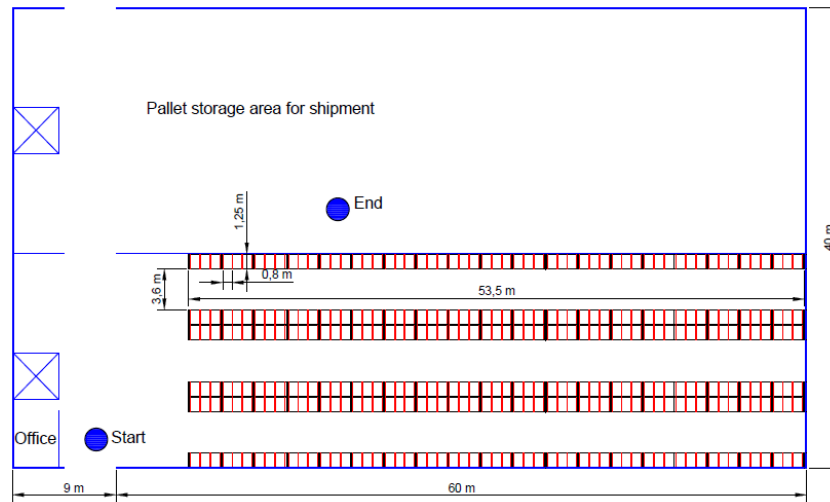
The aforementioned parameters are tested in this paper by using simulation modelling. In the following section, the current operation of picking process is described and modelled via Flexsim software.

PRESENTATION OF THE EXISTING (AS-IS) ORDER PICKING MODEL

The order picking case that is studied, deals with the handling of products of a multinational food and beverage company that acts to more than 200 countries all over the world. The products are fast-moving consumer goods (FMCGs) and

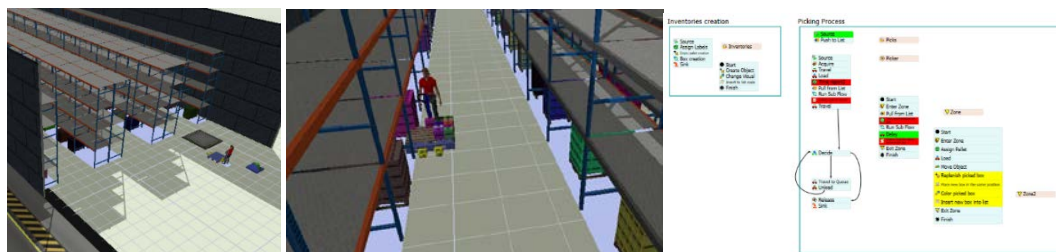
they vary from soft drinks to snacks. In Greece, the company has assigned the storage and distribution operations in a third-party logistics provider namely SYNERGY S.A. Figure 1 shows the layout of the warehouse area that is used to store the products of the company under study.

Figure 1. Layout of the warehouse facility



As it can be seen it consists of 6 back-to-back racks (no. 501-506). Each rack is composed of 6 levels of storage and is divided in 19 bays with 3 pallets slots per bay. The zero level of each rack is used for picking. There are 103 different stock keeping units (SKUs) stored in the racks. The type of packaging material is important in product stacking on the pallets (i.e. the manner products are organized in layers on each pallet). Euro-pallets are used during order picking and a manual pallet truck. The picker collects an empty pallet from a station of empty pallets depicted in Figure 1 and begins the order picking from the “Start” point also shown in the same figure. Each picker is equipped with a handheld scanner and a picking list. The picking method used by the picker is discrete picking and the routing policy is S-type/traversal. After the end of the picking process the picker parks the pallet in the dispatching area shown as “End” in Figure 1. The primary data that were used for this model included 4848 orders. The order-lines of these orders counted 60387. This is a significant workload that, based on the data, requires 2.953.777 seconds of workhours (approximately 820 hours) to complete picking (when a single picker is engaged). The initial aim was to simulate the current operation and then identify alternative scenarios that would be more efficient and cost effective. For simulating the current picking operation, a model was built by using Flexsim software. The latter is a discrete time simulation picking software which combines both visual representation and mathematical methods of simulation. It gives the opportunity to design a warehouse using visual environment of objects from an integrated library. The exact dimensions and distances of the racks, aisles as well as the real picking times were inserted in the simulation model. The results obtained, after running the simulation model, gave a total picking duration of 2.953.771 seconds. This means that we had only a 6 seconds difference compared to the real data; thus, the model was representing very closely the real operation and could be used for comparing the AS-IS scenario with the proposed ones (TO-BE scenarios). Indicative screenshots of the AS-IS model are shown in Figure 2.

Figure 2 AS-IS model layout in Flexsim environment

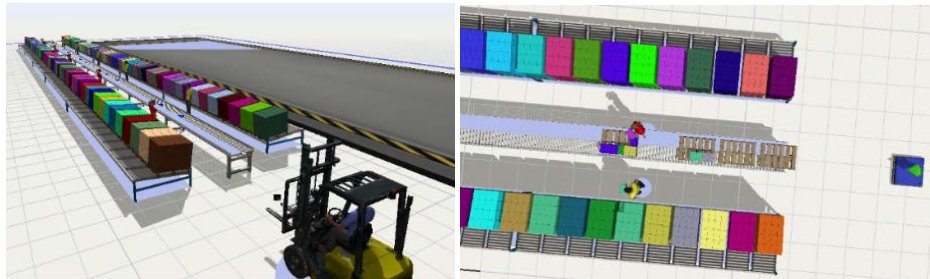


PRESENTATION OF THE PROPOSED (TO-BE) ORDER PICKING MODELS

This section describes the alternative order picking models proposed in this paper. Initially, it is worth mentioning that the products were categorized into types A, B and C according to the picking frequency (ABC analysis using real primary data). Among the 103 SKUs in total, 26 were identified as A-type, 25 as B and the rest 52 as C-type.

The first proposed solution consists of different type of storage equipment. This is called the TO-BE 1 model. In this model, ten live-storage racks are used for storing all the SKUs available. On each rack there are products from all the above types. Moreover, a conveyor belt is used for supporting a zone picking strategy. Ten operators are working simultaneously. Each one has his own picking-list and is responsible for picking certain SKUs. The pickers execute a single order per time. The pallets travel on the conveyor-belt and stop in front of each picker. After the completion of the order the pallet moves to the dispatching area by a forklift. Two different what-if scenarios were tested in this model. In the first scenario we presume that the picker gets one SKU (one carton) in every visit to the rack. So, the total time needed for pickers to accomplish all orders is 1.967.886 seconds. The percentage of time saving is approximately 33,4%. In the second scenario we assume that the picker collects all the items of the order and places them on the pallet. So, walking time is reduced. In that case, the total time needed by the pickers to accomplish all orders is 1.781.080 seconds. The percentage of time saving is approximately 39,7%. In both cases, the total working time (i.e. all picking times are added) for all pickers is considered. In Figure 3 the TO-BE 1 model is shown.

Figure 3 TO-BE 1 model layout in the Simulation Software



The second model developed (To-BE 2) is a hybrid system that consists of two types of storage equipment. The A-type products are stored on four live-storage racks and zone picking method is used. The B and C-type products are placed on back-to-back racks. For B and C-type products, the picker follows the S-Type/Traversal routing policy and the discrete picking method is applied. After the picking of an order is accomplished, two different pallets (1 with A-type SKUs and 1 with the B and C-type SKUs) are placed in a temporary area. Two different what-if scenarios were examined. The first what-if scenario supposes that two different pallets are shipped to the customer. This scenario runs in 2.359.206 seconds and completes all orders in approximately 20,1% less time compared to the AS-IS model. At the second what-if scenario an additional time is added as consolidation time is needed in order to create one pallet per order. In this case the needed time is 2.519.262 seconds which is about 14,7% faster than the AS-IS model. Screenshots of the TO-BE 2 model are depicted in Figure 4.

Figure 4. TO-BE 2 model layout in the Simulation Software

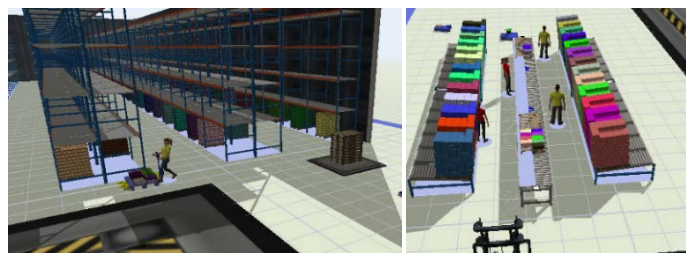


Table 2 shows the results obtained from the proposed TO-BE scenarios. As it can be seen the results obtained are encouraging showing a reduction of total order picking time that varies between 15% and 40%.

Table 2. Results obtained from the two proposed order picking models

TO-BE model	Scenario	Percentage of time saving vs AS-IS
TO-BE 1	1 carton per pick	33,4%
All SKUs in live-storage racks	All cartons in one pick	39,7%
TO-BE 2	Without Consolidation	20,1%
(A-Type SKUs on live-storage racks , B & C-Type SKUs on back-to-back Racks)	With Consolidation	14,7

CONCLUSIONS

The aim of this paper was to investigate the use of alternative storage systems (i.e. live storage racks and conveyor belts) as well as a different picking policy (i.e. zone picking) in a real-life case of a multinational food and beverage company. We presented two what-if scenarios using simulation modelling: (a) implementation of live storage racks where the total number of SKUs are stored, and a conveyor belt used for supporting zone picking strategy, (b) a mixed solution consisting of a combination of live storage (for A-type SKUs) and back-to-back racks (for B and C-type of SKUs) where zone and S-shape/traversal routing policies are implemented respectively. The results obtained are encouraging showing a reduction of total order picking time that varies between 15% and 40%.

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Simulation-Based Schedule Risk Analysis in a Seawater Desalination Plant Construction Project

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Abstract

In the present study, we perform a Monte Carlo simulation-based approach for project delay risks consideration of and prediction of the probability of timely activity completion. The uncertainty of each activity duration is illustrated by the assignment of statistical distributions using a questionnaire answered by an expert. The main contribution of this paper is the development a customized questionnaire for risk factors identification specifically for a seawater desalination plant construction project, and the application of the appropriate statistical distributions to the activities' durations. In addition, Monte Carlo Simulation is used in order to quantify the level of risk that each task and the whole project are exposed to, and assist the project risk manager for accurately predicting the actual project finish time moment. Also, the probability of completing the project at a given date, could be determined, as well. The proposed method applied for estimating the total project completion time of a real seawater desalination plant construction project, in the island of Allonissos, Greece. The present approach, compared to the classic PERT method, provide far more options to the project risk manager for handling effectively the uncertainty regarding project task durations and deadline critical overruns.

KEYWORDS

Project risk management, monte carlo simulation, duration uncertainty, project scheduling

INTRODUCTION

The maximum lifespan of the project is one of the most critical metrics demonstrating effective resource utilization, in order to achieve the deliverables within the required quality requirements. The project forecasted timeline, usually embodies risk because of the controversies regarding the costs and durations of the project tasks. Therefore, time estimations become, very often, difficult problems while scheduling and execution of projects, and solving risk-associated problems is a critical task for effective resource management and timely completion of projects. Classic duration risk analysis methods include the PERT method (Malcolm, Roseboom, Clark, & Fazar, 1959), that inserted uncertain durations to the Critical Path Method (Kelley, 1961). Also, Monte Carlo Simulation used to make time estimations in projects. More specifically, (Vanhoucke, 2012) used Monte-Carlo simulation and real data from earned value management and project schedule risk analysis processes for the development of project efficiency measurements, while (Tran & Molenaar, 2015) quantified project uncertainties using a stochastic simulation approach. Recently, (Koulinas, Xanthopoulos, Tsilipiras, & Koulouriotis, 2020) developed an approach that uses the risk manager's expertise incorporates the experience of the risk manager with Monte Carlo Simulation for project delay risk estimations.

Additionally, several papers studied risks that rise in desalination plants. (Dreizin, 2006) presented water cost risks from the Ashkelon seawater desalination plant and performed cost sensitivity analysis, and (Meghdad, Huat, & Michael, 2011) analyzed the risks and constructed a matrix model for the desalination project plant construction, in Asalouye, Iran. (Bouamri & Bouabdesselam, 2018) used the MADS MOSAR methods to analyze risks to a reverse osmosis seawater desalination plant, and (Fathy Awwad, 2018) performed risk assessments in five different reverse osmosis desalination plants for detecting the main risks that impact such kind of plants.

The objective of this paper is to apply a case-sensitive approach which is based in a simulation process and the preferences of the risk manager, to analyze risks and predict the possibility of the timely completion of an important seawater desalination plant construction project, located in a Greek island. The reminder of the paper is organized by the following sections: (2) the proposed process, (3) the application description and (4) the conclusions section.

THE PROPOSED PROCESS

The proposed methodology can be applied while preparing the final project schedule and before setting a baseline schedule to monitor the project implementation. This study aims at more efficiently predicting the total project duration before its start, and also, while implementing the activities for providing a useful tool for updating makespan predictions with real execution data. The flowchart of the proposed approach is illustrated in Figure 1.

Initially, the proper statistical distribution is assigned to each activity's duration, and a range to illustrate uncertainty, is determined, if the chosen distribution requires it. These are the input values for the Monte Carlo Simulation that follows. The different scenarios results are reviewed and useful conclusions extracted about the acceptance of the total delay risk. If the total amount of risk is not acceptable by the project risk manager, risk reducing actions are performed, and the process returns to the second step, while the manager defines the new, reduced ranges for the activities durations. This iterative process is realized until the total risk is considered as of acceptable level.

Distribution selection and duration deviation range consideration

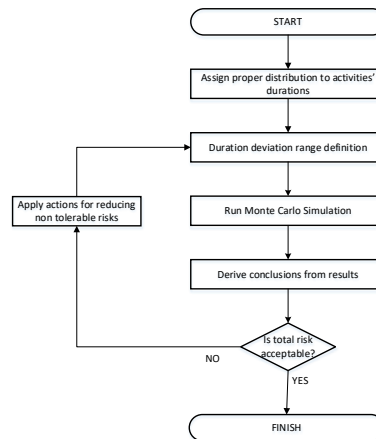
As (Kirytopoulos, Leopoulos, & Diamantas, 2008) referred in their study, it is very important to have access to historical information about the actual duration of activities for efficiently estimating the actual project makespan. However, these data are rarely available to every company, and so, the selection of the right statistical distribution is critical in order to express the uncertainty in activities' durations for proceeding to the simulation process. The main goal is to assign each task's duration the appropriate distribution taking into consideration the nature of the task and the specific characteristics of the distribution. The risk manager, knowing information about the nature and behavior of each task, has to consider the most likely value for the duration, and estimate the lower and upper bounds, in case that the proper distribution needs to. In the present study, we used the triangular distribution since our goal is to express in a practical manner, the continuous uncertainty. The triangular distribution is a popular choice in such cases as it only needs three estimations, namely a most likely value, which corresponds to the base case duration scenario for each task, and a minimum and maximum value corresponding to the manager's optimistic and pessimistic estimation for each task's duration, respectively. These estimations illustrate the experience of the risk manager in such cases when historical data are not available.

More specifically, the expert risk manager taking into account the nature of the task and his previous experience with such projects, has to select the lower (optimistic) value of each task duration, and answering the question about which is the best case scenario for the given task. Also, it must be determined, the upper (pessimistic) value for the deviation range of duration for each activity of the project that is exposed to uncertainty. These estimations are expressed as absolute values of activity's duration (Table 1).

Monte Carlo Simulation and conclusions extraction from results

Monte Carlo Simulation is a risk analysis technique with numerous applications, in which a statistical distribution is used to represent every risk factor (here, each task's duration), and then, a large number of iterations are implemented using several random duration values that belong to the imposed distribution, each one constructing a schedule scenario, and the makespan is estimated. When the total number of iterations is finished, the probability of completing the project within a given deadline can be computed, and useful conclusions could be extracted regarding the actions that the risk managers should perform in order to reduce the non-tolerable risks.

Figure 1. The flowchart of the proposed process



APPLICATION IN A SEAWATER DESALINATION PLANT CONSTRUCTION PROJECT

The proposed process used to analyze duration risks of a desalination plant construction project, where the sea water will be treated with the desalination process for the production of drinking water, on a daily basis, and disposed in the Municipality of Allonissos. All the necessary infrastructure configurations of the surrounding area for the installation and safe operation of water treatment facilities, are the responsibility of the contractor.

The project goal is to ensure drinking water supply in the island of Allonissos. The provision of sufficient quantities' and high quality drinking water, with a controlled rate of supply from the distribution system is necessary, in order to meet the summer's peak demand for the main settlements of Allonissos, but also for the winter, due to the degradation of the available from the drillings and network water sources (salinization).

The expected benefits include the provision of an acceptable quality and quantity drinking water supply for the inhabitants of the island, and the avoidance of groundwater over-pumping that leads to salinization of groundwater aquifers. Completing the project in-time and within budget, is of great importance for the development of the island, the upgrading of the quality of life of the inhabitants and the level of the island's environmental protection. The Monte Carlo Simulation experiments applied using Microsoft Excel 2016 software and, the embedded programming language, Visual Basic for Applications.

The initial schedule impose the project start on 1/9/2020, and finish by 31/12/20, namely a total duration of 95 days computed using the Critical Path Method. Note that the desalination unit must start production at the latest by 5/1/21 (100 days), with delay penalties activated after that date. Given this "latest" possible end date for the project, and without applying schedule risk analysis, the manager knows that the project ends five days before that "hard" deadline. Table 1 includes the key data used for performing Monte Carlo analysis for the project program. In addition, the manager's optimistic and pessimistic estimations for the duration of each is illustrated in columns 5 and 6, respectively.

Table 1 Data for the project example

ID	Activity	Duration	Predecessors	Duration optimistic estimation	Duration pessimistic estimation
1	Start	0		0	0
2	Contract - Project insurance	5	1	5	7
3	Construction site installation	5	2	5	7
4	Configurations and access to the unit installation improvements	15	3	15	18
5	Water intake drilling works	15	3	15	18
6	Sea water supply network construction works	21	3	21	25,2
7	Electricity supply network works Brine disposal and membranes	85	3	85	102
8	leachate disposal network construction	6	4;5	6	7,2

9	Drinking water to the water tanks transmission network construction	15	6;8	15	18
10	Support base construction works	10	9	10	14
11	Supply and assembly of equipment	15	10	15	18
12	Transportation of unit and equipment (sea and land)	4	11	4	4,8
13	Installation of the unit and connections to the rest networks	10	12	10	14
14	Landscaping and completion works	10	12	10	12
15	Finish	0	7;13;14	0	0

The descriptive statistics regarding the project duration, and percentiles for the 1000 simulation iterations that run, are showed in Table 2. Note that, these data are very important for the risk manager in order to consider if the total risk is tolerable or not, and they are used for deriving conclusions from results, as described in the relative step of the flowchart (Figure 1).

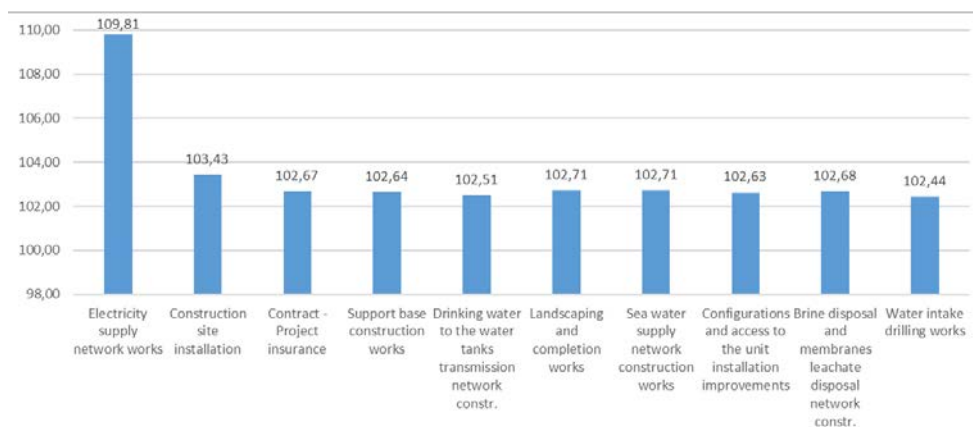
Table 2 Descriptive statistics and percentiles for the total project duration

Descriptives		Percentiles				
Mean	Std Dev	10%	20%	30%	40%	50%
102,00	4,06	97,21	98,14	99,17	100,15	101,25
Min	Max	60%	70%	80%	90%	100%
95,42	114,66	102,54	104,13	105,55	108,89	114,66

The application of the proposed approach shows that the project will surely be extended, since the minimum makespan is 95,42 days. In addition, Table 2 illustrates percentiles for the project makespan. Also, it is very likely that the “hard” constraint of the 100 days will be violated since the probability of the duration to be equal or less 100 days is 38,5%. These findings illustrate the necessity of performing risk mitigation actions in order to preserve the timely project completion.

After the consideration of the project duration possibilities, a sensitivity analysis performed, to clarify the impact of each activity to the total project duration. Figure 2 illustrates a bar chart in which the tasks are ranked according to the “worst” case scenario that they cause to the project duration. Summarizing the graph’s results, the “Electricity supply network works” is, by far, the most influential task since it could extend the project from 95 days to 109,81 days. The second more important task is the “Construction site installation” which can delay the project to 103,43 days. These results provide very important information in making decisions about which task to aim while implementing risk mitigation measures.

Figure 2 Bar chart for the most influential tasks



CONCLUSIONS

In this study, we performed simulation experiments to analyze risk and efficiently estimate delay risks in a desalination unit project plan. Initially, we considered the triangular distribution to express the uncertain duration of each task. The project risk manager determined the upper and lower limit of the distribution's range, using his experience and given that there were no historical data from previous cases. The results are assisting the risk manager to make clearly monitor the probability of in-time project completion. Also, it provides a helpful tool to make making precise predictions about the actual project makespan and considering the most influential tasks so as to prevent their risks. Despite the promising results of proposed approach, it could be improved by analyzing risk factors that affect the project costs, and resources availabilities. In addition, it would be interesting, an extension to group decision making.

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Risk Analysis and Resource Leveling of an Artificial Lake Construction Project

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Abstract

In this paper, we perform analysis of risk factors with impact to the duration of activities and to the total project makespan. The project time uncertainty is assigned to tasks via the assignment of statistical distributions, and Monte Carlo Simulation used to estimate the real level of risk that each activity and the total project are exposed to. These risk levels are used to construct a risk ascending list of activities which is used as a priority list during the resource leveling process. The main contribution of this paper is the development of an approach that uses the risk levels for each activity in order to construct a prioritization approach for assigning constrained resources to activities of uncertain durations, while minimizing resource usage fluctuations.

KEYWORDS

uncertainty, resource leveling, monte carlo simulation, delay, priorities

INTRODUCTION

The estimation of the project makespan under uncertainty, is one of the most important problems that the project risk managers have to deal with while preserving the timely and within budget completion of projects. Risk analysis methods for tasks' durations have been introduced by the classic Program Evaluation and Review Technique (PERT) (Malcolm, Roseboom, Clark, & Fazar, 1959), which was the extension of the Critical Path Method (Kelley, 1961) to uncertain time conditions. In addition, many researchers have been employed the Monte Carlo Simulation for predicting time metrics in projects. More specifically, (Vanhoucke, 2012) used data from schedule risk analysis and earned value management, and performed Monte-Carlo Simulation for the development of project efficiency measurements, while (Bianco, Caramia, & Giordani, 2019) considered a stochastic formulation of the problem, and used Monte Carlo Simulation for scheduling optimization. Additionally, several papers studied risks that rise in water supply projects. (Fylaktos, Mitra, Tzamtzis, & Papanicolas, 2015) used Monte Carlo Simulation for inserting uncertainty in model for technical and economic analysis of an electricity and desalinated water cogeneration plant, and (Kermani & Momeni, 2016) used a fuzzy logic-based framework to manage cost and time risks in projects. In addition, (Ameyaw, Chan, Owusu-Manu, Edwards, & Dartey, 2017) proposed a fuzzy technique for evaluating financial risks in water supply projects. Recently, (Koulinas, Xanthopoulos, Tsilipiras, & Koulouriotis, 2020) proposed an approach that incorporates the experience of the risk manager with simulation for making makespan predictions. Regarding the leveling resources under uncertainty, (Li & Demeulemeester, 2016), developed a genetic algorithm for minimizing the variation in the resource utilization and solving the robust resource leveling problem, and (Li, Zhang, Sun, & Dong, 2020) proposed a greedy algorithm for treating a dynamic resource leveling problem.

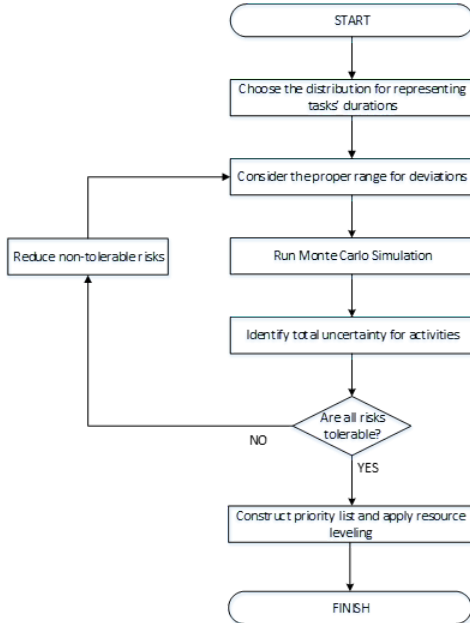
The objective of this paper is to apply an approach that is based in Monte Carlo Simulation for duration risk estimation and then, to use the resulting ranking for prioritizing tasks during constrained resource assignments. This approach is tested on a real project case of an artificial lake in a Greek island. The reminder of the paper is organized by the following sections: (2) the proposed method, (3) the application and (4) the conclusions section.

THE PROPOSED METHOD

The present study aims at the prediction of the total duration of each task before its start, and also, at the estimation of the project makespan. Then, these results are used for prioritizing tasks while allocating the constrained resource. Figure 1 illustrates the flowchart of the proposed method. Initially, the risk manager selects the proper statistical distribution and considers a range to assign time uncertainty. These values are the input for the simulation experiments which applied next. According to the predicted durations for the activities and the project, the risk manager determines if the total risk amount is acceptable or not. In case that the risk is considered unacceptable, the manager has to apply risk reducing actions, and then modifies the ranges for the activities durations. This loop runs until the total risk is

considered as acceptable. Finally, a list of the tasks with descending order regarding their total risk, is constructed, and used as a priority list for performing resource leveling and allocate resources to riskier tasks first, and then to activities with lower levels of risk.

Figure 1 The flowchart of the proposed method



Monte Carlo Simulation duration risk analysis

The main goal of tasks' durations risk analysis is to assign the proper distribution that corresponds to the nature of each activity and the experience of the risk manager. In this study, we assigned the triangular distribution because it can better describe the uncertainty in such cases, and it needs only three estimations about duration, which are, the most likely value, which illustrates the base case duration scenario, and the maximum and minimum value that correspond to the pessimistic and optimistic estimation of the manager regarding the duration of each task. The duration estimations are expressed as absolute numbers. The Monte Carlo Simulation technique applied, works using a statistical distribution to represent each activity's duration, and multiple runs are implemented for a large number of scenarios. The output is a probability of project completion within a deadline, that could be used for considering the total risk as acceptable or not.

Constrained Resource leveling

One of the most difficult problems that the project managers have to deal with, is the resource leveling problem in which the fluctuations in resource usage is tried to be reduced (Leu, Yang, & Huang, 2000), resulting to reduced project costs since there are no changes in resource demand, on a short-term basis. The Constrained Resource Leveling Problem (CRLP) is formulated using an activity-on-node (AoN) network, consisted of n nodes and arcs between nodes. We considered dur_i and f_i , as the duration and the finish time of an activity i , and also, $i = 1$ and $i = n$ for the dummy activities that represent the project start and finish, respectively. The problem is defined as follows:

$$\min M_x = \sum_{i=1}^{f_n} a^2 \quad (1)$$

with respect to

$$f_i \leq f_j - d_j \quad (2)$$

for all precedence relations (i, j)

$$f_1 = 0, dur_1 = 0, dur_n = 0 \quad (3)$$

$$f_n \leq f_n^P \quad (4)$$

$$\sum_{i \in P_t} u_{it} \leq A \text{ for } t = 1, \dots, f_n \quad (5)$$

The Equation 1, describes the objective function which is the minimization of the moment M_x around the horizontal axis of the resource usage histogram. Equation 2 ensures compliance of the imposed, and Equation 3 that the project starts at time zero, while two dummy activities define the project start and finish, respectively. Note that the project cannot finish later than a specified upper bound (Equation 4). Each activity has been assigned one resource R , and a resource availability A considered, while the sum u_{it} of resource usage of all activities P_t that are in progress in a time period t cannot be larger than A (Equation 5).

APPLICATION IN A CONSTRUCTION PROJECT OF AN ARTIFICIAL LAKE

Risk analysis

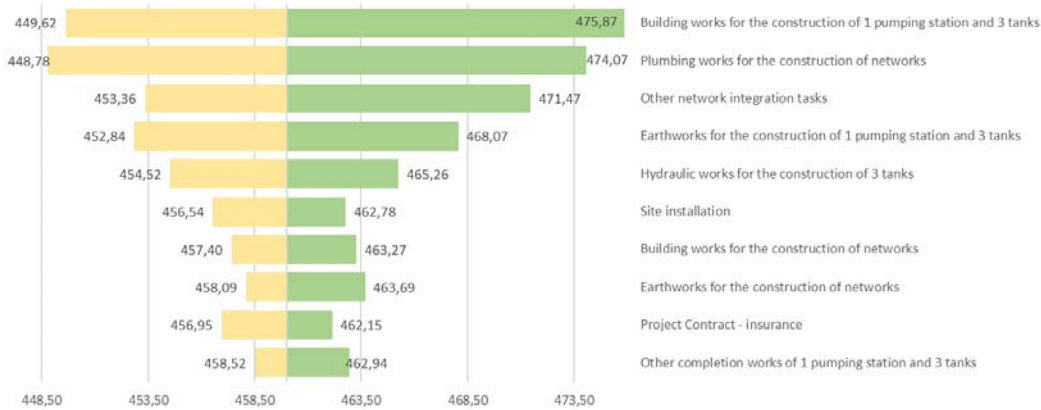
In the present paper, we used the proposed method to analyze duration risks and leveling of an artificial lake project schedule, with a capacity of 510,000.00 m³ of water and its related technical works, i.e. overflow of diversion, water intake and drainage pipeline, located in the island of Allonissos, Greece. This lake will be used for the collection of the water effluents from a small river and their storage needs. The project goal is to improve the residents' quality of life by assisting rational water management with the exploitation and storage of water runoff quantities from the Kastania river that, currently, flow into the sea during the winter season. Also, the satisfaction of the irrigation needs of an area of 700 acres, and the treatment of the water supply problem mainly during summer period when there are very high needs due to the increased number of tourists on the island. The Monte Carlo Simulation performed using VBA which is the programming language embedded in the Microsoft Excel 2016 software. The initial duration of the project, calculated with CPM method was 421 days. The project data, necessary for the simulations are illustrated in Table 1. Also, the risk manager's optimistic and pessimistic estimations about each task's duration are shown in columns 5 and 6, respectively.

After completing 1000 loops of the Monte Carlo Simulation, it was found that the project will be delayed, as the mean duration is 460,02, with a standard deviation of 13,68 days, the minimum makespan is 426,33 days, and the maximum duration could be 506,32 days. These results demonstrate the need for further analysis to identify which activities are most at risk. Thus, a sensitivity analysis performed, to make clear the real impact of each task to the total project makespan. Figure 2 illustrates a tornado graph with activities' ranking according to the range of minimum-maximum project makespan that every activity's duration range causes. It must be noted that the mean duration is 460,02 days. This ranking provides the necessary information about which task to aim while allocating constrained budget to risk mitigation measures.

Table 1 The example project data

ID	Activity name	Duration	Predecessors	Duration optimistic estimation	Duration pessimistic estimation
1	Start	0		0	0
2	Project Contract - insurance	5	1	5	7
3	Site installation	5	2	5	7
4	Earthworks for the construction of 1 pumping station and 3 tanks	30	3	30	42
5	Earthworks for the construction of networks	163	3	163	228
6	Building works for the construction of 1 pumping station and 3 tanks	92	4	92	129
7	Electromechanical works for the construction of 1 pumping station	41	6	41	49
8	Hydraulic works for the construction of 3 tanks	64	6	64	77
9	Building works for the construction of networks	193	5	193	270
10	Plumbing works for the construction of networks	170	8	170	204
11	Other completion works of 1 pumping station and 3 tanks	170	8	170	238
12	Other network integration tasks	55	10	55	77
13	Finish	0			

Figure 2 Tornado graph for activities with the largest impact on the project duration



Leveling of constrained resource

The ranking extracted with the sensitivity analysis, is used as the basic input for prioritizing tasks in allocating a single constrained resource. Thus, we assigned eleven levels of descending priorities each one to a separate task and these priorities (Table 2), and then inserted in the field "Priority" of the Microsoft Project software. The schedule construction was carried out by the software, and the leveling process using the setting "Priority, Standard" for the leveling order. Note that, we considered a daily resource demand of 1 resource unit, for every activity, and the constraint was set to 2 units. the software moves first the task with the less priority value. The initial schedule of 421 days has a M_x value of 2544, and leveling according to the "Standard" order process of the software led to a schedule of 536 days (which considered as the f_n^P of Equation 4) and a M_x of 1892. This makespan extension was expected, as we leveled the project having constrained resource. Leveling project with the risk-based rule has led to a different schedule with a makespan of 536 (which is acceptable because it is equal to f_n^P) and a M_x of 1892, which is equal than the one achieved with the "Standard" rule.

Table 2 Ranking and corresponding priorities for activities

Ranking	Name	Priority
1	Building works for the construction of 1 pumping station and 3 tanks	1000
2	Plumbing works for the construction of networks	900
3	Other network integration tasks	800
4	Earthworks for the construction of 1 pumping station and 3 tanks	700
5	Hydraulic works for the construction of 3 tanks	600
6	Site installation	500
7	Building works for the construction of networks	400
8	Earthworks for the construction of networks	300
9	Project Contract - insurance	200
10	Other completion works of 1 pumping station and 3 tanks	100
11	Electromechanical works for the construction of 1 pumping station	0

CONCLUSIONS

In this paper, we used Monte Carlo Simulation for task duration analysis, and predict time deviations from the initial schedule of an artificial lake construction project. In addition, the tasks were ranked with risk-descending order and this ranking was used as a priority list for leveling the project under constrained resource. The results prove that this approach can assist the risk manager, on the one hand, to estimate probable delays of tasks, and on the other, allocate constrained resource taking into consideration the risk amount of each activity which makes the baseline schedule more robust. Although that the results were promising, the efficiency of the present study would be tested on a wider number of larger projects in order to extract more general conclusions about the risk-based rule performance.

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Session 16:
Multiple Criteria Decision Analysis
chair: Panagiotis Mitropoulos

An application of DEA to measure the efficiency of leading airlines

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Abstract

This paper provides the efficiency analysis of the 30 world leading airlines in 2017 and 2018. Two Data Envelopment Analysis (DEA) models with three inputs and three outputs are developed to assess and optimize the airline efficiency. The basic model evaluates the efficiency of the selected airlines providing satisfactory results. In order to improve these results and to evaluate the operation indicators which affect airline efficiency with the different level of significance, the weighted DEA model is proposed. The weights of inputs and outputs are derived by Analytic Hierarchy Process (AHP). The results include a benchmark, airlines ranking and the directions for improving the efficiency of inefficient airlines.

KEYWORDS

Airline efficiency, DEA, weighted DEA, AHP.

INTRODUCTION

Tense competition among airlines, both full service (FSC) and low cost carriers (LCC) resulted in lower costs and reduced fares for consumers. However in order to achieve better financial results airlines still have to improve the efficiency of their operations. They use the efficiency as the common measure that implies how much a firm can meet its predetermined goals. Nowadays only few airlines in the market have pure LCC or FSC business model. In the recent years there are more evidence of the LCC and FSC business strategies change. The result of these changes is the emergence of the “hybrid” business model that combines the cost-saving methodologies of a pure LCC with the service, flexibility and route structure of a full-service airline. Therefore, we wanted to explore efficiency of 30 leading airlines regardless of their business model. The fact that among efficient airlines we can observe both LCC and FSC airlines, justify our choice to consider them together. Two Data Envelopment Analysis (DEA) models with three inputs and three outputs are developed to assess and optimize the airline efficiency. In the models proposed number of employee, number of aircraft and offered capacity are defined as inputs, while realized traffic, revenue and profit are defined as outputs. The basic DEA model is applied to the set of leading airlines. Moreover, the weighted DEA model is proposed in order to evaluate the operation indicators which affect airline efficiency with the different level of significance. The weights of inputs and outputs are derived by using Analytic Hierarchy Process (AHP). The ability to control weights in DEA model is very useful when some inputs and/or outputs should be entirely disregarded in performance analysis (the weights associated with these inputs and/or outputs are then zero) or their influence should be emphasized/reduced. It gives the ability to a decision maker to take his/her opinion into consideration especially in situations when the decision maker has strong preferences on the relative importance of given factors.

LITERATURE REVIEW

The most popular a non-parametric approach to measure efficiency of comparable organizational units with common inputs and outputs, DEA, is introduced by Charnes, Cooper, and Rhodes (1978), and known as CCR model. There are two basic variants, input- and output-oriented, and it measures efficiency assuming the constant return to scale (CRS). Estimation of efficiency in the airline industry started by Schefczyk (1993) who explored key strategic determinants of high profitability and performance based on the comparison of international airlines. Kuljanin et al. (2017) investigated airline efficiency performance in the turbulent period before and after economic crisis. Kottas and Madas (2018) use DEA with super-efficiency to assess the effect of alliance membership on major international airlines. DEA models have been widely applied in the area of airline efficiency, *inter alia*: assessments of the relative performance of individual airlines around the world (Michaelides et al., 2009); regional studies of major airlines (Assaf and Josiassen, 2011; Cui et al., 2017); in-country studies of individual airlines (Oum et al., 2005; Greer 2008). There are also researches examining the operational efficiency differences between FSCs and LCCs (Chang and Yu, 2014). Many researchers have applied the basic DEA as standalone technique to evaluate efficiency of different airlines in different time period (Scheraga, 2004; Kuljanin et al., 2019, etc.). Moreover, there have been numerous studies

combined the standard DEA approach with different techniques. It can be noticed that DEA approach is combined with the AHP in different ways (Lozano and Villa, 2009; Lai et al., 2015; Babić et al., 2020 etc.). Precisely, DEA could be applied firstly in order to determine efficient units, and AHP to rank them, or AHP could be employed firstly to determine weights which will be incorporated in DEA model. Thus, in this paper the AHP is employed to determine the inputs/outputs weights for weighted DEA model, applied for the first time to assess the efficiency of world leading passengers' airlines.

RESEARCH METHODOLOGY

According to appropriate academic literature it can be seen that the art of managing an airline successfully lies in the ability to balance between capital and labour. In order to assess airline productivity and to offer possible direction of improvements it is necessary to identify the most relevant parameters which should be taken as inputs and outputs. Considering that the goal is to evaluate efficiency of passengers' airlines, both LCC and FS, number of employee (I_1), number of aircraft (I_2) and available seat-kilometres - ASK (I_3) are selected as the inputs, while revenue passenger-kilometres - RPK (O_1), revenue (O_2) and operating profit (O_3) are selected as outputs.

Both proposed models (basic and weighted DEA) would allow ranking airlines according to selected inputs/outputs, and further offering possibility for improve inefficient airlines. The basic model would distinguish efficient and inefficient airlines, while weighted DEA model would reveal the efficient airlines considering different significance of inputs/outputs. To measure the efficiency in DEA models, two components, technical and scale efficiency, are used. The technical efficiency evaluates how best the inputs are converted to outputs, while the scale efficiency pointed out the deviation from the most efficient scale size for a unit under consideration. In the CCR model the main assumption is that the unit operates at constant returns to scale. The applied input-oriented CCR model (input minimization model) determines the relative efficiency of airline by analysing how efficiently the inputs are utilized to produce the given output. Due to the fact that selected outputs could be influenced by an airline to some extent, while inputs can be controlled by the airline, the use of the input minimization model of DEA (CCR) is reasonable.

In DEA model with multiple inputs and multiple outputs, efficiency presents the ratio of the weighted sum of outputs to the weighted sum of inputs. The weights for the inputs and outputs for each DMU are calculated in order to maximize the efficiency of the considered DMU while restricting the efficiencies of the other DMUs within 0 and 1. A general input-oriented CCR model expressed in the following linear programming form (1):

$$\begin{aligned} \min \quad & \sum_{i=1}^m v_i x_{ik} \\ \text{s. t.} \quad & \sum_{r=1}^s u_r y_{rk} = 1 \\ & \sum_{r=1}^s u_r y_{rk} - \sum_{i=1}^m v_i x_{ik} \leq 0, \quad k = 1, 2, \dots, n; \quad u_r, v_i \geq \varepsilon, \quad r = 1, 2, \dots, s, \quad i = 1, 2, \dots, m \end{aligned} \quad (1)$$

where ε is a non Archimedean infinitesimal introduced to insure that all the factor weights will have positive values in the solution.

In order to improve results obtained by basic DEA model we used weighted DEA model in combination with AHP. The AHP is used to determine the significance of the inputs and outputs parameters for weighted DEA model. The pairwise comparison matrices for the AHP are designed based on the authors' knowledge and experience. In order to achieve the goal and find the efficient airlines, the problem is structured as four-level problem. After the overall goal which is set in the first level, inputs and outputs are set in the second level of hierarchy. The third level includes input parameters taken as sub-criteria of input, as well as output parameters considered as sub-criteria of output. Using the local priorities calculated from different levels of hierarchy, it is possible to compute the ratio of different inputs, as well as ratios of selected outputs, which are needed to define significance of the inputs and outputs parameters for weighted DEA model.

DATA AND MODELS APPLICATION

In this research we use the inputs/outputs data of 30 world leading airlines (DMUs) for the years 2017 and 2018 collected from airlines' annual reports (Fig. 1-2). The set of airlines includes 6 LCCs and 24 FSCs from different regions (9 European, 9 American, 9 Asia Pacific, 3 from Middle East and 1 Australian).

Figure 1. Total fleet data for 2017 and 2018

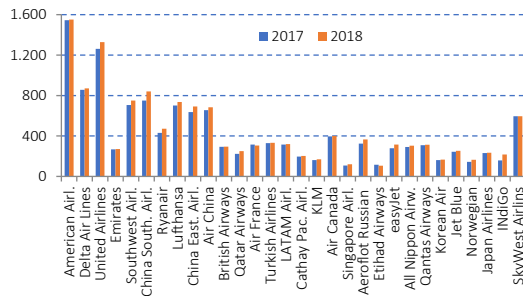
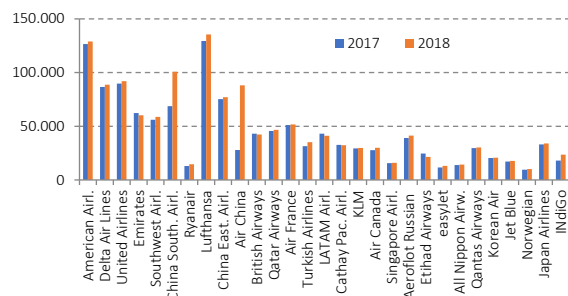


Figure 2. Employees data for 2017 and 2018



Regarding the data we can notice increase in number of employees from 2017 to 2018 in 23 of 30 airlines, while 6 of them slightly reduce the number of employees. Only Air France and Etihad reduce their fleet in 2008. Etihad’s data are generally better in 2017 compared to 2018 (except the revenue, which is negative, but lower than in 2017). Also, Etihad is the only airline with reduced ASK and operating profit in 2018. General observation is that 2/3 of airlines lowered their revenue in 2018.

To define weights for weighted DEA model, the pairwise AHP comparison matrices are based on the authors’ knowledge and experience. According to them, the output is more significant than input; therefore, the local priority for input is equal to 0.3333, while for output it is equal to 0.6667. The pairwise comparison matrices and the local priorities for the second level of hierarchy are presented in Tables 1 and 2, with the required level of the consistency lower than 10%. In order to calculate importance of each selected input and output we multiply local priorities of each input by local priority of input from the first level, and local priorities of each output by local priority of output determined from the first level of hierarchy. Finally, the importance of inputs and outputs are 0.0776, 0.0407, 0.2161, 0.2060, 0.3877 and 0.0730 for I_1 , I_2 , I_3 , O_1 , O_2 and O_3 respectively. These values are further used to calculate ratios needed for weighted DEA: I_1/I_2 , I_3/I_1 and I_3/I_2 , as well as O_2/O_1 , O_2/O_3 , and O_1/O_3 , which are 1.88, 2.82, 5.31, 1.88, 5.31 and 2.82, respectively. These values are incorporated in EMS software to calculate efficiency.

Table 1 Pairwise comparison matrix for the inputs

Inputs	I_1	I_2	I_3	Local priorities
I_1	1	2	1/3	0,2297
I_2	1/2	1	1/5	0,1220
I_3	3	5	1	0,6483

Table 2 Pairwise comparison matrix for the outputs

Outputs	O_1	O_2	O_3	Local priorities
O_1	1	1/2	3	0,3090
O_2	2	1	5	0,5816
O_3	1/3	1/5	1	0,1094

The results obtained by basic DEA model show that there are five efficient airlines in 2017 as well as in 2018 (Emirates, Ryanair, KLM, Singapore Airlines and Korean Air), while all other airlines are found inefficient (Fig. 3). The minimum efficiency in 2017 and 2018 is 74.81% and 65.52% (Qatar Airways), while average efficiency is 90.75% and 90.95%, respectively. It can be noted that among these efficient airlines there is one LCC and four FSC. Also, based on the efficiency ranking of the DMUs, Qatar Airways is identified as the weakest company in 2017 and 2018. The benchmark represents references that can be used to provide the inefficient airline information on which efficient airline it is compared to. For example, the inefficient airline American Airlines is compared to efficient Ryanair and Korean Air. According to the results, Ryanair is the most relevant DMU for the American Airlines, since it has the highest value. Ryanair is benchmark for the largest number of airlines, for even 23. Emirates is benchmark for only one airlines in 2018, while Korean Air is reference airline for 19 airlines, KLM for 14 and 11 airlines in 2017 and 2018, and Singapore Airlines for 4 airlines. Possible improvements of inputs indicate the direction that an inefficient airline approaches to the efficient frontier. Precisely, these values determine the required reduction of the input levels while maintaining the same level of outputs. For example, in order to become efficient American Airlines should reduce the number of employees for 73/72%, fleet size for 39/37% and offered capacity for 13/13% in 2017/2018. The results also show that airlines need additional improvement that can be made by using the slack variables to reach the efficient frontier. It is concluded that there are not huge differences between 2017 and 2018, except in the case of Air China (caused by large increase in number of employees). Another observation is related to the fact that all airlines need to reduce their inputs to achieve efficiency frontier.

Figure 3 Efficiency scores – Basic DEA

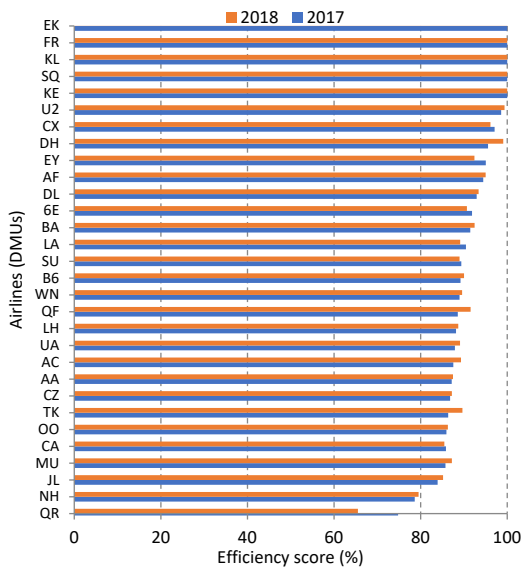
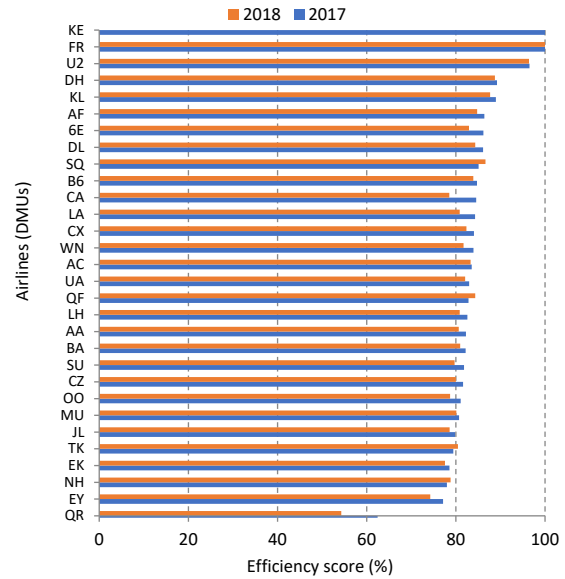


Figure 4 Efficiency scores – Weighted DEA



*American Airl.-AA, Delta Air-DL, United Airl.-UA, Emirate-EK, Southwest-WN, China Southern-CZ, Ryanair-FR, Lufthansa-LH, China Eastern-MU, Air China-CA, British Airl.-BA, Qatar Airl.-QR, Air France-AF, Turkish Airl.-TK, LATAM-LA, Cathay Pacific-CX, KLM-KL, Air Canada-AC, Singapore Airl.-SQ, Aeroflot-SU, Etihad Airl.-EZ, easyJet-U2, ANA-NH, Qantas Airl.-QF, Korean Air-KE, Jet Blue-B6, Norwegian-DH, Japan Airl.-JL, IndiGo-6E, SkyWest-OO

Weighted DEA model reduced the number of efficient airlines offering only two (Ryanair, Korean Air, Fig. 4) for both years 2017 and 2018, which is in accordance to the results obtained in basic DEA model where these two airlines are the benchmark for the largest number of airlines. In this way we avoid a large number of efficient airlines which are actually efficient only due to one parameter performance, while the rest of performances show very poor results (e.g. KLM, Emirates and Singapore Airlines). Also, it is observed that the efficiency scores of all inefficient airlines decreased due to the changed targeted efficiency scores. Moreover, it is shown that the weighted DEA provides better results, since the relationship between the indicators is defined according to their real significance. The minimum efficiency in 2017 and 2018 is 62.46% and 54.3% (Qatar Airw.), while average efficiency is 83.9% and 82.45%. Korean Air is benchmark for 28 airlines, while Ryanair is benchmark for 10/11 airlines in 2017/2018.

Improvements are related to number of employees and offered capacity reduction, while fleet size requires both increase and decrease (it varies from 92% decrease to 104% increase in 2017 and from 91% decrease to 128% increase in 2018). It is interesting to note that rank of airlines according to basic DAE model has been changed. Namely, Emirates fall down on the list to position 27/28 for 2017/18, while KLM and Singapore Airlines stay in top 10 airlines. A significant drop of the Emirates in the ranking position indicates a large inefficiency when it comes to the offered capacity (ASK). LCC are at the top of the range from an efficiency perspective, except Southwest that should improve its efficiency mostly in terms of offered capacity. Higher efficiency by LCC is partially achieved through lower product quality in comparison to FSC. So the required efficiency improvement for the most FSC in the research should be meet but not at the expense of reducing the quality of service to the target customer base. In other words, “efficiency differentiation” between FSC and LCC will always exists, it is only necessary for airlines to recognize those areas in which efficiency can be improved without lowering quality of service.

The results revealed that using the weights it is possible to generate different scenarios and compare them in order to improve the efficiency of inefficient units. An advantage of generating more scenarios with the different weights is that it allows identifying where the largest inefficiencies are and therefore it helps to set priorities. Due to the paper limitation we demonstrate the applicability of the proposed model on one possible scenario. The proposed weighted DEA model can be used by managers and decision makers to get efficiency information based on different weights, to evaluate the performance of airlines and enable them to make more appropriate decisions and strategies.

CONCLUSIONS

Evaluation and improvement of efficiency of airlines is very important in order to enhance capabilities in airline industry. Moreover, evaluating airlines efficiencies helps to improve and increase productivity for survival and growth in the global competitive market. In this paper we use one of the most popular methods for evaluating the relative efficiency

of companies, DEA method, in which there is no need to estimate the production function and there is no limit to the number of outputs and inputs. Also, we evaluate efficiency and rank the airlines by presenting a new model of weighted DEA. The proposed model is applied on real data and the efficiency of 30 world airlines was evaluated and ranked. Expectedly in weighted DEA model, the efficiency of airlines decreased with increasing the preferences of individual inputs. In spite of this decrease, more reliable results for efficiency and ranking of units are provided in weighted DEA model. The model proposed are highly flexible due to the fact that allow decision maker to design AHP pairwise comparison matrices according to his/her knowledge and awareness of current and potential future changes on the market. The weighted DEA model offers possibility to include opinions of different experts in the process of weights selection through the group decision-making or suggesting various “if-then” scenarios based on different assumptions. Since the DEA and AHP are applied in a wide variety of areas, this paper shows that the DEA combined with the AHP can be successfully used as a support tool in airline efficiency evaluation, providing future directions for corresponding improvements. Future research in this field should consider the possibility to use fuzzy sets or fuzzy numbers to express the criteria importance over each other and incorporate account the vagueness of human thinking.

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Session 17:
**Heuristics, Metaheuristics and Nature Inspired
Optimisation Algorithms**
chair: Sotiris Gayialis

Conventional and Electric Vehicles for Freight Distribution: A Case Study in Greece

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Abstract

City logistics and last-mile distribution have gained the interest of practitioners and logistics companies, as well as of consumers and inhabitants. In the case of companies, the objective is to minimize distribution costs and improve the quality of services provided. On the other hand, consumers require fast deliveries and accuracy in time restrictions. Moreover, society and governments are interested in the minimization of greenhouse gas emissions, which greatly affect cities. Addressing effectively the distribution of products in urban areas presupposes the use of advanced algorithms solving optimally the routing of vehicles and scheduling of deliveries, as well as the use of new technology vehicles with minimal fuel consumption and gas emissions. On this premise, the paper proposes a genetic algorithm that addresses the Vehicle Routing Problem with Time Windows and Simultaneous Pickups and Deliveries, while considering the type, characteristics and specifications of the vehicles used. This algorithm is also used for the calculation of the effect of petrol, diesel, and electric vehicles in the logistics sector, and the environment. Therefore, the algorithm is tested and evaluated in real-life distribution cases addressed by a logistics company in Greece. The results obtained from the algorithm are compared and evaluated, while proposals for improving the efficiency of deliveries, as well as for reducing greenhouse gas emissions and costs are made.

KEYWORDS

Vehicle Routing Problem, Electric Vehicles, Time Windows, Conventional Vehicles, Genetic Algorithm, Greenhouse Gas Emissions

INTRODUCTION

According to a research of the United States Environmental Protection Agency, the transportation sector is the largest contributor to anthropogenic U.S greenhouse gas (GHG) emissions, accounting for more than 29%, highest even from Electricity and Industry sectors. The corresponding figure in Europe is 27% according to the European Environment Agency. Among the sources used in this sector (Maritime, Rail, Road, etc.), road transportation cause more than 71% of emissions. More specifically light commercial (LC) vehicles (vans) produced around 2.5% of the total EU emissions of CO₂. On the other hand, Heavy - Duty Trucks that represent only 4% of the on-road fleet in the EU, account for 6% of the total EU CO₂ emissions.

On this premise, EU set target levels and regulations regarding GHG emissions, in its effort to reduce them. However, these targets are hard to be detained in many cases, since the commercial vehicles used in the distribution process are of old technology, with all that entails. More specifically, Greece has the oldest light commercial (LC) and medium and heavy (MHC) commercial vehicles among the countries of the European Union (EU) according to the European Automobile Manufacturers' Association (ACEA) "Vehicles in use" report. The average age of LC vehicles in EU is 10.9 years, and of MHC 12.4 years, while the corresponding figures in Greece are almost twice, and more specifically, 18.9 and 20.9 years respectively. Based on the same research, most EU countries have limited petrol-engine vehicles and have invested mainly in diesel vehicles, as shown in Table 1. Greece remains relatively behind in this case as well, since it holds the smallest percentage of diesel trucks, and the highest in unknown fuel type, due to the lack of information since the vehicles are almost 20 years old. The age of the vehicle and the type of the engine are the main characteristics that determine the fuel costs, the noise and CO₂ emissions, which is of great importance nowadays. The distribution cost, probably remains the most significant factor over the years, not only for logistics companies, in their effort to be competitive in the market but for consumers as well, in their search for the most value for money product. On the other hand, noise and GHG emissions are significant for inhabitants, especially in city centers, and their reduction has become the number one priority for the EU.

Table 1. Comparison of Vehicles in Greece and EU

Type of Commercial Vehicles	Region	Average Age	Petrol	Diesel	Hybrid electric	Electric	LPG + Natural Gas	Other + Unknown
Light	Greece	18.9	41.50%	37.30%	0.00%	0.00%	0.00%	21.20%
	EU	10.9	7.10%	91.20%	0.00%	0.30%	1.30%	0.10%
Medium and heavy	Greece	20.9	0.10%	56.10%	0.00%	0.00%	0.00%	43.80%
	EU	12.4	1.00%	98.30%	0.00%	0.00%	0.40%	0.20%

Considering all the above characteristics, the transfer from the current state into the future, which will include a complex distribution network with multiple challenges, imposes the need for investments in new technologies related to vehicles, as well as to routing software. Software can efficiently address the Vehicle Routing Problem (VRP) and reduce operational costs, only if variants, variables and constraints that logistics companies face in their daily distribution operations have been clearly identified and integrated into the system. According to Gayialis et al. (2019), the VRP with Time Windows (VRPTW) is among the most studied variants of the VRP. It reflects most in real-life distribution cases faced by logistics companies, as most customers determine a time slot that a vehicle must arrive. The same applies in the VRP with simultaneous pickups and deliveries (VRPSPD), as most customers in real-life have both a delivery and a pickup demand, so that delivery items start from the depot, and pick up items return to the depot (Wassan and Nagy 2014).

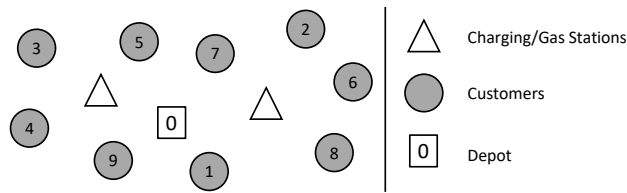
Furthermore, while the distribution of goods has attracted the interest of researchers for more than 60 years, it is only the last few years that the GHG emissions are considered in the VRP, due to the ecological awareness of transport sustainability, leading to green logistics. In the case of Electric VRP (EVRP), the vehicles that are used for the distribution process, have electric batteries. This implies a limited driving range, as well as visitations to Charging Stations (CS) in order to recharge the batteries, when needed, for executing the routes (Erdelić et al. 2019). However, the EVRP can be much more challenging and complex if we consider that battery consumption and CO₂ emissions are related to the load and the speed of the vehicle (Lin et al. 2016). Erdelić and Carić (2019) present a survey on the EVRP, and more specifically they focus on consumption models, as well as on additional emerged EVRP variants, such as hybrid vehicles, charging stations, charging functions and dynamic traffic conditions. However, we make the assumption that consumption and CO₂ emissions are fixed, irrespectively the load and the speed of the vehicle.

Finally, the objective of the present paper is first to propose a genetic algorithm that can optimally address the Electric Vehicle Routing Problem with Time Windows and Simultaneous Pickups and Deliveries (EVRPSPDTW), as well as handle real-life data of customers, vehicles and refueling stations. Consequently, the algorithm is tested in real-life distribution cases, addressed by a logistics company in Greece, in order to calculate and compare the economic and environmental footprint, when the fleet of vehicles is only composed of petrol, diesel and electric vehicles. The remaining part of this paper is organized as follows: Section 2 presents the description of the EVRPSPDTW. Section 3 presents the algorithmic approach, Section 4 the computational data, while in Section 5 the conclusions are analyzed.

PROBLEM DESCRIPTION

The Electric Vehicle Routing Problem with Time Windows and Simultaneous Pickups and Deliveries (EVRPSPDTW) states that a set of identical vehicles denoted by K , start from the depot and need to serve a set of customers. $G = \{F \cup N, A\}$ is a graph, where vertex $N = \{0, 1, \dots, n\}$ is the set of nodes, vertex $F = \{n + 1, n + 2, \dots, n + s\}$ is the set of charging stations (CS), and $A = (i, j): i \neq j, i, j \in N$ denotes the set of arcs. The central depot is represented by 0, and $N^* = \{N/0\}$ represents the customers. Each arc (i, j) indicates a path from node i to j , characterized by the distance d_{ij} and the travel time t_{ij} . Each customer has a specific demand q_i to be delivered, a specific demand r_i to be picked, a specific service time s_i , and indicates a time window (e_i, l_i) , where e_i is the start of the time windows, and l_i the end. The restriction that applies in the specific variant of the VRP is that customers must be served only once, by a single vehicle, while the vehicle may arrive before the start of the time window, and wait until the time window opens, but never after the end of the time window. As for the capacity restriction, since both delivery and returned items are considered, in every arc, the vehicle's capacity cannot be violated. Finally, each vehicle is characterized by a maximum driving range a_k , which is the distance that can be traveled when the tank or the battery is full, until empty, as well as by the recharging or refueling time c^k , which is the time required to recharge the battery at full capacity, or fill the tank, depending on the type of the vehicle.

Figure 1. Distribution Case with Charging Stations



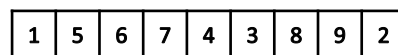
ALGORITHMIC APPROACH

Over the years, multiple algorithms have been developed for solving the different variants of the VRP. Initially, exact and heuristic algorithms were implemented, even if each category has specific disadvantages. More specifically, exact algorithms can offer optimal solutions but cannot handle more than 100 customers in most cases, due to the increased computational time needed. On the other hand, heuristics can handle large-scale instances in limited computational time, but at the expense of solution quality. Finally, metaheuristic algorithms balance both factors, as they offer near-optimal solutions in short computational time. Therefore, we developed a metaheuristic algorithm, and more accurately a genetic algorithm, for addressing the EVRPSPTW.

Genetic Algorithms (GA) belong in the class of Evolutionary algorithms, and are inspired by the process of natural selection. Initially, a set of solutions is constructed. In the present paper, we apply the time-oriented nearest neighbor algorithm, as proposed in Solomon (1987), for the construction procedure. Consequently, in each generation, the selection of solutions (chromosomes) based on a fitness-based procedure is applied, for defining the solutions, called parents, that will be exploited and combined for creating new solutions. Each new solution, called child, is produced by a pair of parents, and by using the procedures of crossover and mutation. The crossover and mutation operators that are applied in our case are the same that are used in Ombuki et al. (2006). This process ultimately leads to a new population of solutions, composed of parents and children. The procedures of selection, crossover, and mutation, are the key pieces of GA's, and are applied for a specific number of generations (repetitions), that have been set. In the present paper, the population size is 30, and the maximum number of generations is 30.

Furthermore, each solution in the specific GA is presented by an array of length equal to the number of customers. The objects of the array, called genes, contain integers that correlated to the customers' ID. Additionally, the sequence of genes determines the visitations of vehicles to customers, as well as the routes. Each time the capacity or the time window constraint is violated, a new route starts. However, in the case of vehicles, that have limited driving range, we also consider the need either of recharging before the battery is discharged (electric vehicles), either of refueling the tank (conventional vehicles). Therefore, between two consecutive genes, a charging or a gas station (GS) may intervene, but simultaneously the station's ID is not contained in the chromosome. Additionally, both the time and the distance required for the vehicle to reach the CS or GS are taken into account. In Figure 2, a chromosome with 9 customers is presented as an example. In case the driving range of a vehicle, which has fully charged batteries, or a full tank, is not enough for executing a route, then the vehicle must visit a CS or a GS, according to the type of vehicle. For example, in Route 1 of Figure 2, after the vehicle serves customer 6, needs to visit a CS or a GS for recharging or refueling, in order to be able to execute the route. The possibility of a visit to a station (CS or GS) is greater in electric vehicles due to their limited driving range.

Figure 2 Chromosome Structure



Route 1: 0 - 1 - 5 - 6 - CS - 7 - 0

Route 2: 0 - 4 - 3 - 8 - 0

Route 3: 0 - 9 - 2 - 0

Finally, the objective function in the present paper, which is also used in the fitness-based procedure, is the minimization of the total distribution cost. The total cost is composed of the fixed cost (cost per vehicle used) and the variable cost (€/Kilometer).

COMPUTATIONAL DATA

The distribution cases that are studied in the present paper, are faced by a logistics company in the city of Athens, Greece. The data of the customers (57 in total), contain their addresses, their demand and return quantities (Kg), as well as their time windows. More specifically, we test 5 different cases, in order to extract more reliable conclusions.

Starting from the first case (Case 1), and until the last one (Case 5), the quantities of goods that each customer requests, either to be delivered or to be returned, increase in size, and constitute a bigger part of the vehicle's capacity.

As for the vehicles that are considered in our research, we discriminate three cases according to the fuel type, (i) Petrol, (ii) Diesel, and (iii) Electric vehicles. However, in order to extract reliable conclusions from our research, the vehicles are of the same brand (Nissan), and more specifically the same model (NV200). Consequently, the distribution cases are tested for the three different vehicle types. In each case, the fleet of vehicles is composed only of the same type of vehicles. In addition, the fixed costs were calculated, taking into account depreciation time (10 years) and annual vehicle use (250 working days per year). The increased fixed cost of electric vehicles is at least expected since the purchase price is higher than the other types of vehicles. On the other hand, the variable cost is inversely proportional to fixed costs, since it depends on the value of fuel. Furthermore, the driving range in the case of electric vehicles is significantly lower, and leads to the need for battery recharge, which is also time-consuming (45 minutes to fully recharge the empty battery). Batteries also cause another problem, which is the reduced capacity. However, all the above disadvantages are balanced by the zero CO₂ emissions.

Table 1. Features and Specifications of Vehicles

Vehicle Type	Fixed Cost (€)	Variable Cost (€/Km)	Driving Range (Km)	Capacity (Kg)	CO ₂ Emissions (gr/km)
Petrol	8.00 €	0.0972	750	795	166
Diesel	8.82 €	0.0555	1100	728	131
Electric	11.70 €	0.0196	275	630	0

COMPUTATIONAL RESULTS & CONCLUSIONS

The computational results of our research, containing the number of vehicles needed (number of routes) to execute the plan of routes, the total distance, CO₂ emissions and the costs (variable, fixed and total), are calculated for each vehicle type (Petrol, Diesel, and Electric), as well as for each distribution case. Table 4, Table 5 and Table 6 contain the results of Petrol, Diesel and Electric vehicles respectively.

Table 2. Economic and Environmental Impact of Petrol Vehicles

Case	Number of Routes	Total Distance (Km)	CO ₂ Emissions (Kg)	Fixed Cost (€)	Variable Cost (€)	Total Cost (€)
1	4	378.82	62.88	32.00	36.82	68.82
2	5	392.93	65.23	40.00	38.19	78.19
3	5	427.78	71.01	40.00	41.58	87.58
4	8	527.09	87.50	64.00	51.23	115.23
5	9	561.64	93.23	72.00	54.59	126.59

Table 3. Economic and Environmental Impact of Diesel Vehicles

Case	Number of Routes	Total Distance (Km)	CO ₂ Emissions (Kg)	Fixed Cost (€)	Variable Cost (€)	Total Cost (€)
1	4	377.25	49.50	35.28	20.93	56.21
2	5	413.29	54.14	44.1	22.94	67.04
3	6	421.71	55.24	52.92	23.41	76.33
4	9	563.91	73.87	79.38	31.30	110.68
5	9	630.35	82.58	79.38	34.99	114.37

It can be easily observed that petrol vehicles have the highest CO₂ emissions. Diesel vehicles have also increased emissions, but they gain significant interest due to their low distribution cost. As for electric vehicles, emissions are zero but at the expense of high distribution cost compared to other cases of vehicles. The main factor affecting deliveries with electric vehicles, leading to increased cost, is that in each distribution case more vehicles are needed to execute the deliveries compared to the other types of vehicles. That is due to the limited capacity of electric vehicles, as batteries have increased weight and volume, which prevent them from having the same capacity as other types of vehicles.

Table 4. Economic and Environmental Impact of Electric Vehicles

Case	Number of Routes	Total Distance (Km)	CO ₂ Emissions (Kg)	Fixed Cost (€)	Variable Cost (€)	Total Cost (€)
1	5	394.64	0	58.5	7.72	66.22
2	6	432.91	0	70.2	8.48	78.68
3	7	469.17	0	81.9	9.19	91.09
4	10	617.21	0	117.00	12.09	129.09
5	11	640.09	0	128.70	12.55	141.25

Surely, Greek companies should invest at least to diesel vehicles that will offer both decreased CO₂ emissions and distribution costs, if not to electric. According to Table 1, 41.5% of LC vehicles in Greece are petrol, 37.3% diesel, while the rest are unknown. That means, if the composition of vehicles is equivalent in the distribution cases we study, we could decrease at least 10.70% the CO₂ emissions and 5.39% the distribution cost, by changing petrol vehicles with diesel.

Finally, in Case 1, where each customer has small demand, in terms of weight, multiple customers can be integrated into the same route. As a result, the number of electric vehicles that are utilized in deliveries are not much more than conventional vehicles, and therefore fixed costs are on the same level. Additionally, the variable costs remain very low in the case of electric vehicles, unlike to conventional vehicles. On the other hand, when the items are of bigger size (Case 5), the total distribution cost of electric vehicles is much higher, due to the increased number of vehicles needed. In conclusion, electric vehicles could be very efficient, both in terms of cost and CO₂ emissions, in distribution of small size items such as parcels and mail. In order to validate this assumption, more cases need to be tested as a further research.

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Optimal Segmentation of Student Classes for Social Distancing

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Abstract

The pandemic situation due to COVID-19 forced activities that involve social gathering to postpone their physical operation. At some point in time, the critical situation is expected to de-escalate, and careful steps must be made to return to normality. New modes of operation for educational institutions, government agencies and various businesses emerge in the period between “closedown” and full normal operation. High schools, being much crowded places, restart their operation with segmented student classes of smaller sizes. Students are asked to be present at school premises day by day, to lower the risk of spreading the virus. So, an interesting scheduling problem arises. Given that before the “closedown”, each student belonged to specific classes based on common courses and selected direction courses, a new grouping of students to classes is asked. The objective is to have the best possible balanced student classes according to students that were enrolled to the original classes, while keeping a near perfect balance between total students that are present at the school facilities every day. In this paper, the underlying optimization problem is formulated and test cases of high schools in Preveza, and Agrinio Greece are presented. The problem is solved using heuristics and Integer Programming (IP). Results comparison reveals the advantage of the IP approach since it reaches optimal solutions in negligible time.

KEYWORDS

Social distancing, Student class segmentation, Heuristics, Integer programming.

INTRODUCTION

In year 2020, COVID-19 a novel coronavirus originally identified in Wuhan, China quickly escalated to a worldwide health issue. At March 11, WHO (World Health Organization) made the assessment that COVID-19 could have been characterized as pandemic. Since no known drug at that time could treat effectively affected patients, social distancing and personal hygiene habits were proposed as the basic measures of protection against uncontrolled spread of the virus.

In response to the unfolding crisis, the Greek government at March 22, announced transport restriction measures. A few days earlier, at March 10, schools and universities were closed. Almost two and a half months later, epidemiological data suggested that it was safe to reopen high schools. So, Greek authorities decided to open high schools at May 11 (for the twelfth grade), under new regulations that promoted social distancing. Each student was assigned to one of two shifts over two-week periods. The first shift included Monday, Wednesday, and Friday of the first week and Tuesday and Thursday of the second week. The second shift included the complimentary days. The rationale was to halve the student population that were present at every day at the school premises. So, each high school had to split student classes that pre-existed into subclasses and assign each individual student to the appropriate shift.

PROBLEM DEFINITION

Lyceums in Greece include tenth, eleventh and twelfth grades in schooling. Students of the twelfth grade must take the Pan Hellenic examinations to be admitted to the Higher Education. So, twelfth grade poses a physical and psychological challenge for students and their families. Typically, Pan Hellenic Examinations start at the last days of May but in year 2020, due to COVID-19, they were scheduled to start at June 15. So, starting at May 11 students of the twelfth grade returned to their schools. A week later, at May 18 the other two grades of Lyceums and the seventh, eighth and ninth grades (Gymnasium) also returned.

Each student belongs to a class for common taught courses and also belongs to another class for courses taught according to the direction that he or she chose at the start of the school year. The new social distancing regulation dictates that all student classes that have more than 15 students must be segmented. So, classes with 15 or less students are kept as is. A portion of the data of a problem instance is shown in Table. Aggregated data are also shown in Table. Students should be assigned to shifts trying to keep the total number of students in each shift as close as possible. Moreover, when a class is separated the two parts of the class should have almost the same number of students. For

example, if a class has 23 students then it is preferable to have two subclasses with 12 and 11 students. All other segmentations are less desirable as shown in Table. The third column of the table shows the number of students that must be moved from the shift with more students to the shift with less students to balance the resulting student classes.

Table 1. A portion of a problem's data (preveza_2lyceum_12)

Student Id	Common Courses Class	Direction Courses Class
2664	G1	AS1
2672	G1	AS1
2673	G1	THS1
2688	G2	AS1
...
2758	G5	YG

Table 2. Number of students per class (preveza_2lyceum_12)

Class	# students
G1	23
G2	24
G3	23
G4	24
G5	23
AS1	18
AS2	19
THS1	13
THS2	14
SOP1	20
SOP2	18
YG	15

Table 3. Possible segmentations of a student-class with 23 students

Shift A	Shift B	Even segmentation distance
12	11	0
13	10	1
14	9	2
15	8	3
16	7	4
17	6	5
18	5	6
19	4	7
20	3	8
21	2	9
22	1	10

The problem belongs to the broader class of educational timetabling problems (Kristiansen and Stidsen, 2013) which mainly includes course timetabling, examinations timetabling (Gogos et al., 2012) and high school timetabling (Valouxis et al., 2012).

SOLUTION APPROACHES

Equalizer heuristic

Heuristics are fast methods, able to produce "good enough" results to complicated problems. Being custom designed for each given problem, they usually capture some idea that steers the solution process to the right direction. Heuristics, in general, reach sub-optimal solutions and give no information about how far the obtained solutions are from optimal ones.

A simple heuristic that can be used to solve the problem follows. Firstly, all classes with fifteen or less students are sorted in descending order of size and, in turn, all their students are assigned to either shift A or shift B. Then all other classes are examined, and each student is assigned to the shift that currently has the smaller number of students already assigned to it. The heuristic balances student population between the two shifts but gives no guarantee about balanced splitting of individual student classes.

Of course, simpler, or more complex heuristics can be devised. For example, a simpler heuristic would keep the first part of the equalizer heuristic, that assigns all students of small classes to a certain shift, and then it could assign each of the remaining students one by one to alternating shifts. Unfortunately, this heuristic would probably miss a close to perfect total balance among student population between shifts if the small classes number is odd. A more complex heuristic might have tried to penalize all individual classes imbalances and then assign each student in turn to the shift that minimizes the added penalty. Another simple alternative, which is later used in the experiments, runs multiple times the equalizer heuristic shuffling randomly the set of students in each run, and then keep the best solution.

Exact methods – Integer Programming

Exact methods can find optimal solutions, provided that the size of the problem is manageable. Among them, Integer Programming (IP) is particularly well suited for combinatorial optimization problems. A model of the problem is build, based on specific constructs and assumptions and a IP solver is then employed.

To solve the student class segmentation problem using IP, a mathematical model is formulated. Let us assume that the total number of students that should be segregated in the two shifts (A and B) is TS . Let C denote the set of student classes that are used to teach common courses. For each class c in C , let SC_c be the set of student ids that belong to the class. Similarly, let K be the set of classes that are used to teach direction courses and for each class k in K let SK_k be the set of student ids that belong to class k .

Then, for each i in $1..TS$, let x_i be a binary variable that assumes value 0 when student i is assigned to shift A, or value 1 when the student is assigned to shift B. Moreover, binary variables b_k are defined such that when a direction student class has 15 or less students, then all of them are assigned the same shift, either A or B.

The following variables are derived based on values assumed by variables x .

- Integer variable y : Distance from the even separation of all students to the two shifts.
- Integer variable dg_c : Distance from the even separation of student class c to the two shifts.
- Integer variable $totdg$: Summation of dg_c for all c in C .
- Integer variable dp_k : Distance from the even separation of student class k to the two shifts.
- Integer variable $totdp$: Summation of dp_k for all k in K .

The objective is to minimize the sum shown in Equation 1.

$$\text{minimize } y + \text{totdg} + \text{totdp} \quad \text{Equation 1}$$

subject to:

$$y = \left\lceil \left\lfloor \frac{TS}{2} \right\rfloor - \sum_{i=1}^{TS} x_i \right\rceil \quad \text{Equation 2} \quad dg_c = \left\lceil \left\lfloor \frac{|SC_c|}{2} \right\rfloor - \sum_{i \in SC_c} x_i \right\rceil \quad \forall c \in C \quad \text{Equation 3}$$

$$\text{totdg} = \sum_{c \in C} dg_c \quad \text{Equation 4}$$

$$dp_k = \left\lceil \left\lfloor \frac{|SK_k|}{2} \right\rfloor - \sum_{i \in SK_k} x_i \right\rceil \quad \forall k \in K: |SK_k| > 15 \quad \text{Equation 5}$$

$$\text{totdp} = \sum_{k \in K: |SK_k| > 15} dp_k \quad \text{Equation 6}$$

$$\sum_{i \in SK_k} x_i = b_k * |SK_k| \quad \forall k \in K: |SK_k| \leq 15 \quad \text{Equation 7}$$

It should be noted that Equation 7 can also be used to group various students that for some reason have to belong to the same shift.

Since the absolute value function is nonlinear, the following trick, which is demonstrated for equation 2, is employed to remove the nonlinearity. Variable y assumes the lowest possible nonnegative value since y is included in the objective value which should be minimized.

$$y \geq \left\lfloor \frac{TS}{2} \right\rfloor - \sum_{i=1}^{TS} x_i \quad \text{Equation 8} \quad y \geq \sum_{i=1}^{TS} x_i - \left\lceil \frac{TS}{2} \right\rceil \quad \text{Equation 9}$$

Using both floor and ceiling functions in Equations 8 and 9 ensures that the correct deviation value is computed. The same trick is used to remove the absolute function from equations 3 and 5.

A small problem might be the fact that the objective function in Equation 1 using variables $totdg$ and $totdp$ as defined in Equations 4 and 6, cannot discriminate whether the penalty comes from one or more unbalanced student classes. In an extreme case all classes but one might be perfectly balanced, but this one class might be highly unbalanced which is clearly undesirable. A better solution should distribute penalties among all classes. This can be achieved by replacing Equations 4 and 6, with Equations 10 and 11. Of course, this changes the problem to a nonlinear optimization problem and a special solver capable of handling nonlinear equations is now needed. Fortunately, the SCIP solver (Gamrath et al., 2020) can handle nonlinear constraints and is able to solve problems with this formulation.

$$\text{totdg} = \sum_{c \in C} dg_c^2 \quad \text{Equation 10} \quad \text{totdp} = \sum_{k \in K: |SK_k| > 15} dp_k^2 \quad \text{Equation 11}$$

EXPERIMENTAL RESULTS

Experiments of the solution approaches were conducted over two sets of problem instances. The first set included real problem data that were given from high schools at Preveza and Agrinio, in Greece. The second set was artificially generated making reasonable assumptions about the general characteristics of student classes in Greece. The IP solver was programmed using the Python interface of the SCIP 7.0 Optimization Suite. Experiments were run on a Windows 10, Intel Core i7 7700K, 16GB RAM workstation. Under this configuration the running time of the IP solver for each problem instance was less than a second.

Real cases problem instances

Three problem instances were obtained from high schools in Greece. The first two were taken from the 2nd Lyceum of Preveza and were of the twelfth and eleventh grade. The third problem instance was obtained from the twelfth grade of the 4th Lyceum of Agrinio. A fourth problem instance was constructed by joining data from the two Preveza's problem instances. Table 1 summarizes those data.

Table 1. Real cases problem instances

Problem Instance	# of students	# of common classes	# of direction classes
preveza_2lyceum_12	117	5	7
preveza_2lyceum_11	111	5	6
preveza_2lyceum_11_12	218	10	13
agrinio_4lyceum_12	105	5	6

Table 1 shows the results of running a) the Equalizer Heuristic 5000 times and then keeping the best solution and b) the IP solver. Each point is a balance violation representing a student that if moved to the other shift, better balance of a class or total population of students between the two shifts would have been achieved. The IP solver consistently finds the optimal values and outperforms the heuristic.

Table 1. Equalizer Heuristic (best over 5000 runs) vs IP Solver results

Problem Instance	Equalizer Heuristic (5000 runs)	IP Solver
preveza_2lyceum_12	6	5
preveza_2lyceum_11	7	6
preveza_2lyceum_11_12	16	8
agrinio_4lyceum_12	9	4

Figures 1 and 2 show class sizes when the two solvers are applied to the preveza_2lyceum_12 problem.

Figure 1. Equalizer Heuristic (1 run) - Penalty=19, SHIFTA=59(50.43%) SHIFTB=58(49.57%)

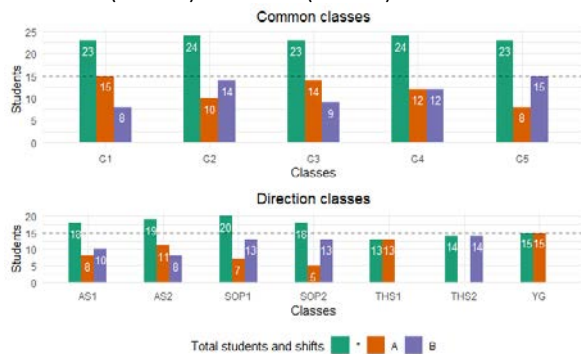
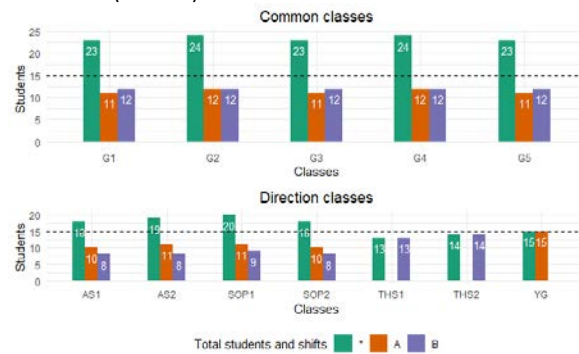


Figure 2. IP Solver - Penalty=5, SHIFTA=57(48.72%) SHIFTB=60(51.28%)



Artificially generated problem instances

To test the solvers in more problem instances a problem generator was created. The basic assumptions of the generator follow. No class can have more than 27 students. Students are assigned to common courses classes. The number of those classes is $\lceil \frac{TS}{27} \rceil$ where TS is the total number of students. Since each student should choose one among a number of directions, students are also assigned to direction course classes, again adhering to the precondition that no class should enroll more than 27 students. The direction of each student is selected randomly based on parameterized direction percentages that are given to each generator run. The directions and typical percentages for the twelfth grade for the 2019-2020 school year were: humanities (32%), economics and informatics (32%), exact sciences (23%), health sciences (13%). These values were used for the experiments which are shown in Table , alongside with results obtained

by the two solvers. The name of each problem instance ends with the number of students. The IP solver finds optimal solutions for all instances and the optimality gap of the heuristic grows as the problem size becomes greater.

Table 2. Artificially generated instances and results

Problem Instance	# of common classes	# of direction classes	Equalizer Heuristic (5000 runs)	IP Solver
ag_50	2	4	2	2
ag_100	4	6	5	5
ag_300	12	13	14	0
ag_500	19	22	37	0
ag_1000	38	40	90	0

CONCLUSIONS

Several optimization problems exist in everyday life. Moreover, when typical conditions change or when resources must be shared under new regulations, opportunities arise for better decision making. Computer based decision support gives the potential of reaching financial and convenience benefits. In year 2020, the pandemic situation, resulted in general lockdown for several countries where schools closed and after a period reopened under social distancing rules. We solve the problem of student classes segmentation to two shifts to halve the student population that is present concurrently at school facilities. The problem is solved sub-optimally using heuristics and then solved optimally using Integer Programming. Execution times for both approaches are negligible. It is concluded that heuristics, can provide good solutions with minimal effort, but when applicable, exact methods like Integer Programming give superior results. Our algorithm can reach optimal solutions even for large schools assigning to the proper shift hundreds of students.

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Session 18:
Intelligent Systems in Transportation
(ENIRISST workshop)
chair: Dimitrios Dimitriou

Assortment of needs and prospects for developing an intelligent services system in transport sector

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Abstract

Modern business management based on dynamic risk analysis and combination of real time data towards operational efficiency on one hand; and corporate management performance on the other. This paper deals with the analysis of the real requirements for digital services to support policy making, strategic and business planning and decision making in transportation sector. Key objective deals with the determination of the needs for a data driven management system (platform) upon the development of intelligent services to support decisions in sector of transportation. The research outputs based on the results of a questionnaire survey addressed to transport and logistics sector, providing results about the real needs for data analytics, event observation, cost-benefit analysis, market trends and forecasting, for a variety of potential users in supply chain business ecosystem. Adopting a System of System (SoS) approach the utility of data driven service in the real business is addressed considering each transportation system capabilities and network capacity constraints. Special emphasis is given to analyze the content, define the expectation and utilize the need for the development of an intelligent combined data driven system addressing the system utilization for the different group of potential users' expectations, prospects, organizational structure and governance. Conventional wisdom is to provide state-of-the-art research outputs for managers, planners and decision makers towards business intelligence and corporate strategy in transportation sector.

KEYWORDS

Intelligent services, Research Infrastructure, Questionnaire Survey, Prospects in Transportation, Assortment of needs in Transportation

INTRODUCTION

Research Infrastructures (RIs), from large facilities such as CERN to distributed data networks, play a vital role in Research and Innovation and recent years have seen a strong growth in the number of RIs that are operational or planned across Europe (ESFRI, 2017). Moreover, they are key investments in research in all areas as they meet both the demand of the scientific community for state-of-the-art resources for supporting excellent science, and the demand of knowledge transfer for innovation at social and economic level (ESFRI, 2018). This paper deals with the analysis of the real requirements for digital services provided by an intelligent and pioneering RI, in order to support policy making, strategic and business planning and decision making in transportation sector.

EN.I.R.I.S.S.T PROJECT OVERVIEW

EN.I.R.I.S.S.T. is a unique and pioneering Research Infrastructure that aims to fill a significant existing research gap in the fields of Shipping, Supply Chain and Transport in Greece. It combines the collection and processing of data (with the aim of protecting privacy and copyright), the development of innovative models and programming techniques, the development of useful applications, secure and user-friendly, and finally the development of digital observatories aimed at support for public and private stakeholders (businesses, public bodies, research organizations, etc.)(EN.I.R.I.S.S.T, 2020). In this way, the vision of EN.I.R.I.S.S.T. is to become a center of excellence that will promote and support research in its scientific fields. The objectives of EN.I.R.I.S.S.T. are:

- Develop an intelligent research and business platform to support key economic activities and small and medium-sized enterprises active in the areas of research infrastructure interest.
- Collect process and provide researchers and users with information & tools on national & international passenger & freight transport including sea, air, inland and intermodal transport.
- Support stakeholders in original research, investment plans and policies (academic community, researchers, infrastructure operators, private & public companies, policy makers)
- To create a multi-dimensional institution of economic & research development for Greece, by creating new & enhancing existing networks that will ensure the flow of knowledge & information

The Intelligent Research Infrastructure EN.I.R.I.S.S.T. is composed of 11 Partners which include 8 Educational Institutions and 3 Research Centers in Greece. Researchers specialized in shipping, supply chain and transportation, as well as software developers, come together and unite their expertise. This specialization promotes research excellence, ensures an integrated approach to the challenges of the above sectors, leading to successful implementation of the infrastructure. In addition to the major partners, the EN.I.R.I.S.S.T. infrastructure ecosystem is made up of Industry

Representatives, Private Companies, Public Enterprises, Policy Makers, Independent Researchers and Citizens (Source: EN.I.R.I.S.S.T., 2020: <https://www.enirisst.gr/>).

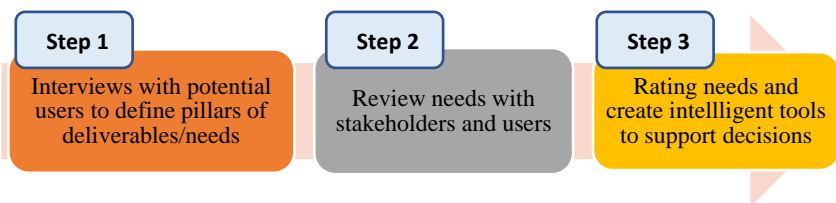
METHODOLOGY BACKGROUND

The overriding consideration in choosing an analysis methodological framework is that the results must facilitate the decision making process of the organizational managers. The essential requirement is that the analysis outputs should be understandable and reasonable for the users. Therefore, the results outputs should be accurate, timely and understood by the users so that to use the analysis outputs help them to produce better decisions. The recognition that any analysis techniques operate on the data generated by historical events and situations leads to the identification of the following three step in Infrastructure architectural developing process:

1. Data collection – (Development of data base)
2. Modell building – (Creation of metadata warehouse)
3. Model extrapolation – (Service outputs and interface)

In order to develop EN.I.R.I.S.S.T. Research Infrastructure, it is necessary to consult with potential project users in order to gather their requirements and needs regarding the research infrastructure’s services related to shipping, transport and supply chain activities. This process is performed in 3 steps, as shown in Figure 1.

Figure 1. Depiction of process to define the RI outputs.



QUESTIONNAIRE SURVEY BACKGROUND

The questionnaire is the research instrument based on different set of questions for gathering information from the respondents across various fields. According to Rowley (2014), questionnaires are one of the most widely used means of collecting data and therefore many novice researchers in business and management and other areas of the social sciences associate research with questionnaires. Although there are some standards for questions design, a crucial part in a survey represents the empirical evaluation of questions through focus group discussions, cognitive interviews, in which people’s comprehension of questions and how they go about answering questions is probed and evaluated and field pretests under realistic conditions (Stephanis et. al, 2007). Generally there are two types of questions: open-response and closed-response questions (Farooq R., 2018.). Open-response questions give respondents an opportunity to answer the question in their own words. Closed-response questions give respondents a choice of answers and the respondent is supposed to select one. There are advantages and disadvantages to using one type of question versus another.

Sampling can be used to make inference about a population or to generalize in relation to existing theory. In essence, this depends on choice of sampling technique (Dimitriou et. al, 2006). In general, sampling techniques can be divided into two types (Taherdoost H., 2016):

- Probability or random sampling;
- Non- probability or non- random sampling

EN.I.R.I.S.S.T Survey Scope

Based on the above process (Figure 1), a questionnaire survey is applied in order to gather and review the potential users’ needs and prospects in shipping, transport and supply chain sectors, in accordance with relevant international practices and the needs of potential users operating in Greece. The visualization of the requirements of potential users will relate to the use of data and post-data to support decisions at the strategic planning level and scale of regional administrative structure, with distinct subsystems the critical transport hubs (airports, ports, railway stations, central railways) with special emphasis on the Greek trans-European transport network. For this reason, a questionnaire was created in order to gather, capture and consult the requirements and needs of potential users of the platform.

EN.I.R.I.S.S.T Survey Characteristics

The questionnaire is anonymous and was performed in 2 phases; with interviews with potential users (executives and researchers in the field of transport and related specialties) (Phase A) and by sending an electronic version from a suitable web platform to potential users and organizations (Phase B). The main key features of the questionnaire are presented in Table 1:

Table 1. Questionnaire key features.

Questionnaire collection	
Phase A	150 questionnaires
Phase B	100 questionnaires
Collection period	
Phase A	October 2019 to April 2020
Phase B	November 2019 to June 2020
Size	6 closed-ended questions and 1 open-ended question
Sampling method	Simple random sampling
Categories of respondents Institutions/ Organizations	<ul style="list-style-type: none"> - Central government - Local government - Equipment or infrastructure construction/marketing - Means of transport operation - IT services - Transport-Logistics infrastructure management - University - Research Institution - Advisor - Consultant

EN.I.R.I.S.S.T Survey Results

In this section, the preliminary results of the questionnaire survey to determine the needs of potential users of EN.I.R.I.S.S.T research infrastructure are summarized.

Figure 2 shows the distribution of respondents according to the category and governance framework of the institution/organization to which they belong. Regarding organization category, the majority of respondents belong to higher education sector (65.7 % in University and 15.7 % in Research Institution), while the fewest of the respondents belong to an institution/organization related to IT services and construction. Regarding the governance framework, the vast majority of respondents belong to University (68.7 %), followed by the private sector (15.7 %), general government (13.4 %), public sector (9.7 %) and research institution (8.9 %).

Figure 2. Institution/ Organization Category (left) and governance framework (right).

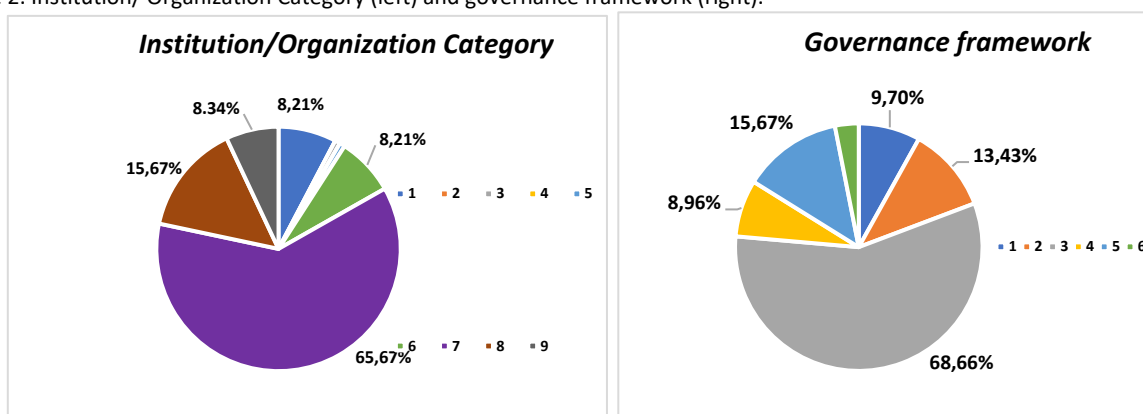


Figure 3 shows the organization /institution's ability to access data management platforms related to transport, shipping and/or supply chain. The majority of respondents do not have access to data management platforms related to maritime heritage (97.8 %), land and intermodal transport (84.3 %) and transport infrastructure (73.2 %), while half of the respondents' state that they have access to data management platform related to passenger transportation.

Figure 3. EN.I.R.I.S.S.T. potential users' access to data management platforms.

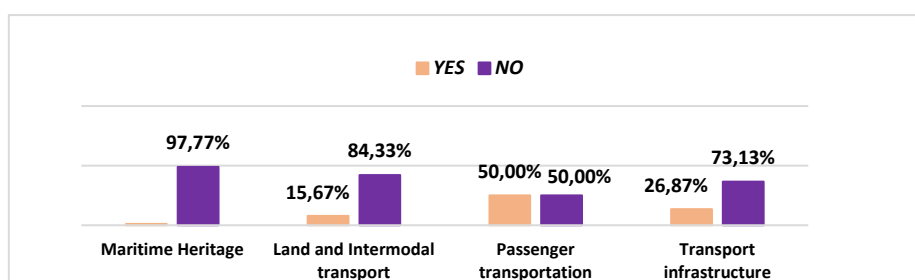
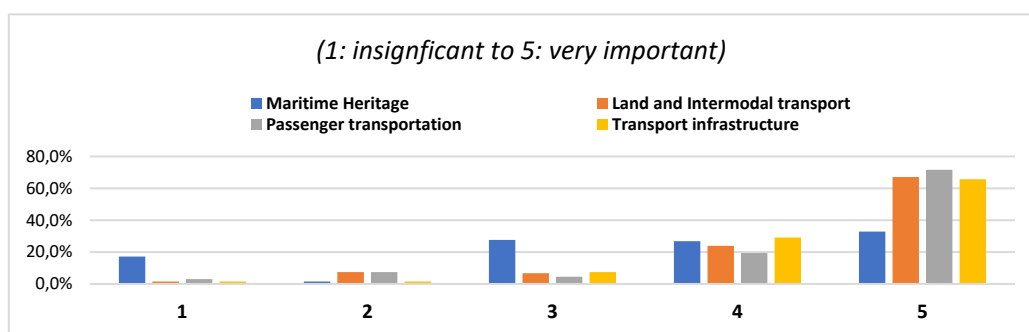


Figure 4 shows the importance evaluation of data management platform development to the operation of respondents' organization/institution. The evaluation is carried out in a scale from 1 to 5, where 1 is equivalent to 'insignificant' and 5 to 'very important' rate. The respondents assessed the development of all the proposed platforms as 'very important'. The largest percentage of evaluation as 'very important' is presented by the transport infrastructure platform (71.6%), while the smallest by the maritime heritage platform (32.8%).

Figure 4. Level of importance for developing data management platform for the transport sector business ecosystem.



Regarding the services that will be developed by EN.I.R.I.S.S.T., which are considered to meet the needs of the respondents' organization/institution, they are divided in services related to shipping and land/ air transport and supply chain services. In the shipping sector, most respondents chose services related to financial data analysis (80%), decision-making support (70%), shipping pollution and impacts on the environment (70%) and financial product information (42.5%). In land/air transport and supply chain sectors, the services with the highest percentage of selection by the respondents are related to road safety data observatory, passenger traffic monitoring, intermodal transport information, autonomous vehicles application development, freight transport demand forecasting and transport and logistics market monitoring, with a percentage over 97%.

Table 2. Evaluation of the institution/organization needs meeting by EN.I.R.I.S.S.T. proposed services (1: insignificant to 5: very important)

Institution/Organization Needs	1	2	3	4	5
Strategic planning	2.23%	2.23%	14.93%	41.04%	44.78%
Transport trends and prices monitoring	2.23%	2.99%	10.45%	47.01%	42.54%
Fleet management	23.88%	23.00%	28.36%	8.21%	20.15%
Financial management	9.70%	15.67%	23.13%	16.42%	41.04%
Human resources management	10.45%	15.67%	35.82%	10.44%	33.58%
Business plan development	3.73%	32.08%	13.43%	20.89%	35.82%
Financing scenarios development	1.49%	14.18%	15.67%	42.53%	30.58%
Development of new services for users / passengers / market	15.67%	9.70%	27.61%	21.64%	29.10%
Competition monitoring	14.18%	9.70%	14.17%	30.59%	36.57%
Development / Implementation of new investment plans	2.99%	8.96%	17.92%	38.81%	36.57%
Management Support - Corporate Governance	4.48%	23.00%	28.36%	17.91%	30.58%
Corporate performance monitoring	34.32%	4.47%	24.63%	24.63%	16.42%

Subsequently, Table 2 presents the assessment of the needs of the respondents' organization/institution to be covered by the proposed services of the project in the sectors of shipping, transport and supply chain. These needs are related to data collection and monitoring, data analytics and decision making. The evaluation is carried out in a scale from 1 to 5, where 1 is equivalent to 'insignificant' and 5 to 'very important' rate. The vast majority of respondents assess as 'very

important' the needs of their organization/institution that will be covered by the proposed services. The needs with the higher rating are related to strategic planning (44.8 %), transport pricing monitoring (42.5 %), financial management (41 %) and development of new investment plans and competition monitoring (36.6 %).

Finally, the vast majority of respondents (92.5 %) believe that their organization/institution has the ability to provide data and / or contribute to EN.I.R.I.S.S.T research infrastructure. In the shipping sector, the largest percentage of respondents are available to provide traffic (100 %), economic (75 %) and financial data (75 %). In land/air transport and supply chain sectors, the largest shares in data provision are related to travel demand forecasting (80 %), road safety data (70 %), passenger traffic data and indicators development for intermodal transport evolution (60 %) and transport and logistics market activities monitoring (55 %).

CONCLUSIONS

Transport infrastructure, which includes physical networks, terminals and intermodal nodes, information systems, as well as refueling and electrical supply networks, is necessary for the safe, secure operation of road, rail, civil aviation, inland waterways and shipping and is crucial to the European Union's (EU) economic growth and social development (Dimitriou et. al, 2020). In order to address current socio-economic challenges within an ever-changing complex and competitive environment, the transport sector requires new technological developments (Sartzetaki et. al, 2019). Moreover, Research Infrastructures play a key role in the advancement of knowledge and technology and provide an important link in the innovation chain. The purpose of a RI is to provide metadata to support transport sector business ecosystem (operators, authorities and organizations) to observe and monitoring up to day performance, assess internal and external risks and support decisions in planning, management and financing. This paper deals with the analysis of the real requirements for digital services to support policy making, strategic and business planning and decision making in transportation sector. Key objective deals with the determination of the needs for a data driven management system (platform) upon the development of intelligent services to support decisions in sector of transportation. The research outputs based on the results of a questionnaire survey addressed to transport and logistics sector, providing results about the real needs for data analytics, event observation, cost-benefit analysis, market trends and forecasting, for a variety of potential users in supply chain business ecosystem.

ACKNOWLEDGEMENT

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Assessment methodology and outputs towards sustainability and resiliency in transportation

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Abstract

The Paris Climate Agreement in 2015 provided an opportunity for countries to strengthen the global response to the threat of Climate Change by promoting the need of emissions mitigation. Subsequently, the United Nations' 2030 Agenda for Sustainable Development promote a series of 17 Sustainable Development Goals, which adopted by all UN Member States the same year. Hence, the subject of sustainability is crucial for the modern world, where economic and social activities focused on changes to achieve prosperity and be resilient. The necessary condition, that is, ensuring economic, social and environmental sustainability, also affects the functioning of critical organizations and businesses, especially for the transport sector, which is a key pillar of any economy. Global sustainability challenges are shaping the way business operates in the 21st century. Businesses are under increasing pressure from multiple stakeholders (e.g. shareholders, customers, employees, society) to manage their positive and negative impacts with clear responsibility and strategic intent. In this paper, the methodology framework deals with analysis of risk assessment and transport business performance evaluation towards their ability to meet the goals of sustainability. Conventional wisdom is to evaluate rate of management response and how corporate actions can be best configured to promote responsible and sustainable business strategies, which is a major challenge for planners, managers and decision makers.

KEYWORDS

Transportation Analytics, Decision Making, Environmental Impact Assessment, Business resiliency, Risk management, Sustainable Transport

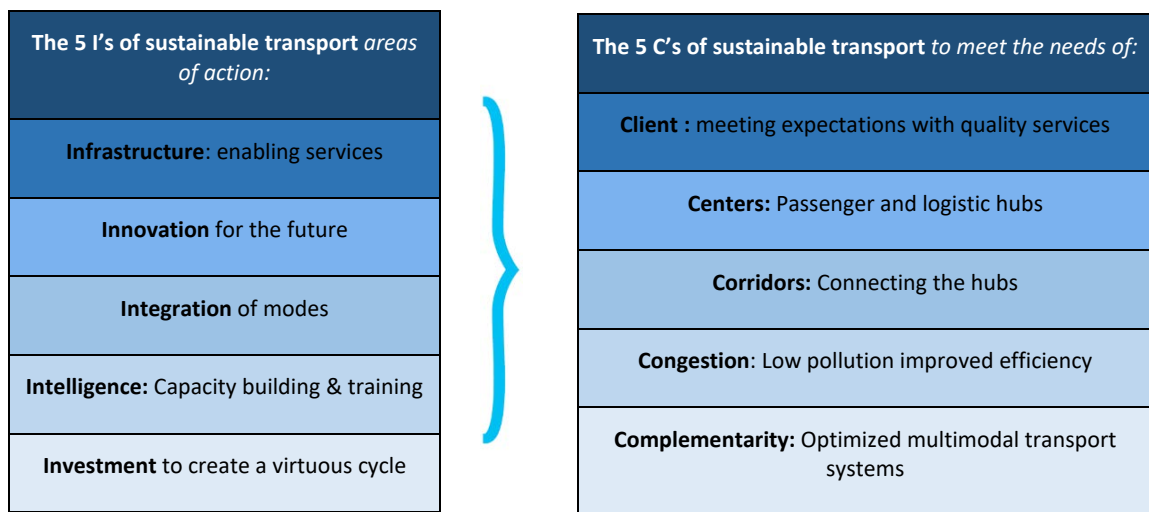
INTRODUCTION

Transport is a major contributor to economic growth that requires operational productive and efficient infrastructures and services. The necessary condition, that is, ensuring economic, social and environmental sustainability, also affects the challenges and opportunities facing the built environment and, especially, the functioning of critical organizations and businesses (Dimitriou et. al, 2019). Global sustainability challenges are shaping the way business operates in the 21st century. Businesses are under increasing pressure from multiple stakeholders (e.g. shareholders, customers, employees, society) to manage their positive and negative impacts with clear responsibility and strategic intent. Hence, the transformation to sustainable transport requires a redirection, rather than any substantial increase, in infrastructure expenditure (United Nations, 2016). The need for new approaches in transport planning, management and policy development, new technology, and the global resolve toward achieving the 2030 Agenda for Sustainable Development and the Paris Climate Agreement is crucial for the operation of modern businesses (United Nations, 2019).

SUSTAINABLE TRANSPORT

Effective transport planning combines the need for short-term deliverables with a long-term strategic view, incorporating the social, economic and environmental aspects of transport and of development more broadly (Dimitriou et. al, 2006). While consideration of both short- and long-term needs is common sense for all planning, it is particularly relevant for transport because of its multi-faceted nature and the resource-intensive, locked-in quality of many transport infrastructure and systems decisions (United Nations, 2016). The business case for sustainable development becomes increasingly clear with longer time horizons. Investing in green energy, or resilient infrastructure, for instance will save—and earn—money for companies over the long-term (Dimitriou et. al, 2010). For private sector companies, and even, as noted above, for local and national governments, competition is a powerful driving force, and competing to become more sustainable will pay dividends over the long-term for the companies, the governments and the world at large. Resilience planning is an important feature of sustainable transport development, ensuring that passenger and freight transport networks including infrastructure, service and operations are able to adapt well to climate change-related events and other chronic stresses, such as high unemployment and endemic violence and acute shocks, such as earthquakes and terrorist attacks.

Figure 1. Areas of action and key targets of Sustainable Transport, (Source: United Nations, 2016)



Transport Business Sustainability Performance

Businesses have a big responsibility in the transition process to sustainable development. The business managers should find ways and tools for balance the organizations performance in different dimensions. Tracking their performance in triple-bottom-line, permits evaluate the pertinence of corporate sustainability goals defined and identify gaps and critical points. In the last 15 years, more than a hundred standards and management solutions were developed to evaluate and report the economic, social, environmental and sustainability performance of companies like ISO, Advisory Group on Corporate Social Responsibility (Medel-González et. al, 2013). The importance of indicators for measuring business performance has been widely used by managers. Sustainable development indicators and composite indicators are considered to be a good vehicle in helping to measure sustainable development and progress achieved in it. Companies' reporting should abide by the Global Reporting Initiative (GRI) Standards and is in line with their sustained commitment to the United Nations Global Compact, the acknowledgement of the United Nations' Sustainability Development Goals (SDGs) and the Agenda 2030, contributing to the global sustainability effort and taking into consideration economic, environmental and social criteria.

CASE STUDY

Athens International Airport

Athens International Airport S.A. (AIA) was established in 1996 as a public private partnership with a 30-year concession agreement, the Airport Development Agreement (ADA). Ratified by Greek Law 2338/95, the concession agreement grants the Company the exclusive right and privilege of the 'Design, Financing, Construction, Maintenance, Operation, Management and Development' of the new Athens International Airport. AIA is a privately managed company with the Greek State holding 55% of shares (25% held by the Greek State and 30% by the Hellenic Republic Asset Development Fund-HRADF), while private shareholders collectively hold 45%. Overall, in the year 2019, the Athens International Airport recorded an all-time high performance with 25.57 million passengers, surpassing previous year's traffic by 1.4 million (+6%). This outcome was solely driven by the robust growth of the international market (+1.4 million or +8.6%), while the domestic market retained prior-year levels (+0.3%).

In line with the Airport Company's sustaining commitment to the United Nations Global Compact, AIA adopts and upholds the related sustainability principles for Human Rights, Labour Relations, Environmental Impact and Anti-Corruption. Furthermore, the Airport Company acknowledges the United Nations' Sustainability Development Goals (SDGs) and the Agenda 2030, contributing to the global sustainability effort (AIA, 2018).

Sustainability Perspective

AIA participates in Airport Carbon Accreditation (ACA), a voluntary initiative launched by the European region of Airports Council International (ACI Europe), aimed at helping airports map and manage greenhouse gas emissions under their control which eventually evolved into a global programme following the induction of all other ACI regions. To date, the company has reduced its carbon footprint by almost 50% compared to its 2005 baseline. In 2018, AIA maintained its carbon neutral accreditation (ACA Level 3+) by zeroing out its residual carbon emissions (AIA, 2018). This was accomplished by purchasing Guarantees of Origin from its local electricity supplier through the 'Greenpass program' that ensures that all electricity consumed by AIA was produced by renewable energy sources. It was also accomplished

by purchasing verified carbon offsets for AIA's other remaining emissions (e.g. its vehicle fleet), which ensure that these emissions were neutralized by clean energy produced in other parts of the world.

Table 1. Athens International Airport Carbon Footprint, (2018).

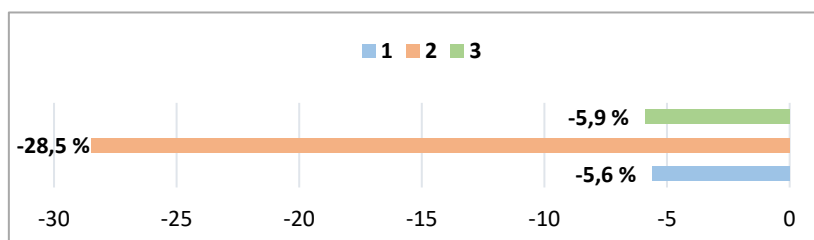
Source: Athens International Airport (AIA). Annual & Sustainability Report 2018

	Source Type	Consumption	CO ₂ Emissions (t)
Scope 1	Natural Gas	925,762 Nm ³	1,945
	Vehicle Fleet	91,806 lt of petrol	209
		487 lt of LPG	1
		451,947 lt of diesel	1,210
	Stationary Sources	28.514 lt of diesel 7,632 lt of heating oil	76 21
Scope 1 TOTAL			3,462
Scope 2	Grid Electricity	58,276,594 kWh	35,490
	Scope 2 TOTAL (Location based)		35,490
	Scope 2 TOTAL (Market Based)		0.0
Total (Scope 1 and 2)			38.952

The total energy figure (Electricity & Natural Gas) for 2018 was increased mainly due to the significant growth in the Passenger and Aircraft Traffic, paired with the year's weather conditions. On the contrary, the "Consumption per Pax" KPI has improved. This demonstrates the Airport has continued strong performance in energy efficiency. During 2018, AIA's Photovoltaic Park produced 12,948.4 MWh of renewable energy, lower by 5.4% than the previous year, mainly due to the unfavorable weather conditions in the second half of 2018. The energy produced was equivalent to 13% of the Airport's total electricity consumption or 25% of AIA's own electricity needs. Overall, regarding total energy consumption per passenger, in 2018 there was an overwhelming reduction in natural gas consumption compared to 2017 (-25.8 %), while a smaller decrease was observed in electricity consumption (-5.6 %).

Figure 2. Variation (%) of total consumption per passenger at Athens International Airport facilities, (2018/2017).

Source: Athens International Airport (AIA). Annual & Sustainability Report 2018

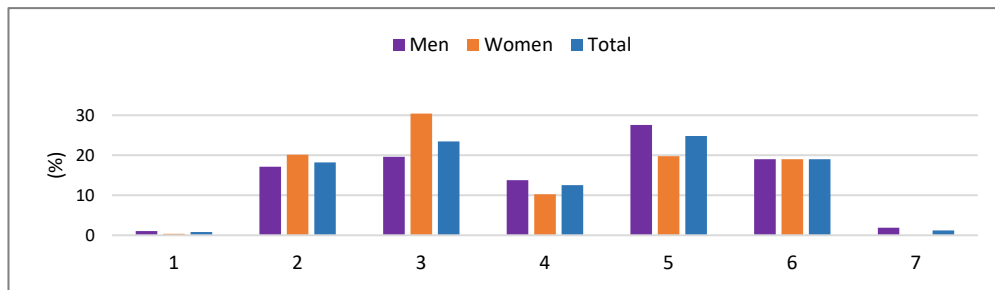


Social Perspective

At the end of 2018, the company's headcount was 589 people under open-ended contracts and 153 under contract. All AIA employees are employed on a full-time basis. The average age of the employees is 45.1 years old. A high percentage amounting to 31% of the company's personnel reside in the local communities reflecting its close relationship with the Mesogeia community. The entire management team resides in the Attica Region. In 2018, 35% of all employees were female, a ratio that might appear low, is however fully justified by the nature of the more technical and/or manual job positions offered by AIA. Women made up 16.7% of management. According to company's latest Sustainability Report (AIA, 2018), considerable importance is given to the educational level of its workforce and its aim is to attract and retain highly qualified employees. Hence, AIA's personnel is well educated and a significant proportion of them hold postgraduate degrees. Figure 3 shows the company employees' educational status distribution in 2018. Regarding the total number of AIA's employees, the majority have a university (23.4 %) or college degree (24.8 %), while a significant percentage hold a master's degree (18.2 %). In terms of gender distribution, the majority of male employees have a college degree (27.6 %), while women have a university degree (30.4 %).

Finally, the company invests significantly in training and innovation programs. AIA's Innovation programme aims to continue cultivating a culture of forward thinking, promote collaboration and encourage the production of new ideas across the organization. It is therefore open to all AIA employees who are eager to contribute with new and creative ideas. At the same time, the Airport is a significant driver of economic development in the region. This is complemented by targeted investments in social, educational, cultural, athletic, environmental and other initiatives that go well beyond the scope of any legal obligations and help establish the Airport as a good neighbor.

Figure 3. Athens International Airport employees' educational profile distribution (%)
 Source: Athens International Airport (AIA). Annual & Sustainability Report 2018



Attikes Diadromes S.A.

Attica Tollway, being a pioneer in modern motorways in Greece, whose construction began in 1996 and the first part of it opened, along with Athens International Airport to which it connects, in March 2001. It aims at actively contributing to the reduction of road accidents in Greece, providing top services to its users as well as to all drivers. "ATTIKES DIADROMES S.A." is the company, which has undertaken the operation and regular maintenance of Attica Tollway. The companies "ATTIKA DIODIA S.A." with a participation of 80% (the shareholders of which are the shareholders of the concession company) and the French company "EGIS ROAD OPERATION S.A." (ex Transroute International) with a participation of 20% participate in "Attikes Diadromes S.A.". In 2018, the average daily traffic was increased by 4.21%, compared to the previous year. More specifically, 82,502,880 vehicles used Attica Tollway, which means an average of about 226,035 vehicles per day. July was the busiest month with a daily average of 246,217 vehicles (Attiki Odos, Annual Report, 2018).

In 2017, the company adopted the Goals of Sustainable Development Goals-SDGs), as evidenced by Agenda 2030 of United Nations, trying to strengthen the achieving of the objectives associated with the its activity and aiming to promote security and prosperity, environmental protection, gender equality and work ethic.

Sustainability Perspective

For the evaluation of the company's carbon footprint the "Bilan Carbone®" method is used and the areas of operation included are energy consumption, transport, depreciation and waste management (Attiki Odos, Annual Report, 2018). Greenhouse gas emissions remained almost at the same level as in 2017, with a small decrease of 0.33%, comparing the data concerning only 'Attikes Diadromes SA', as the footprint was counted until 2017.

Figure 4. Variation (%) of company's consumption (2018/2017)
 Source: Attiki Odos, Corporate Responsibility Report 2018

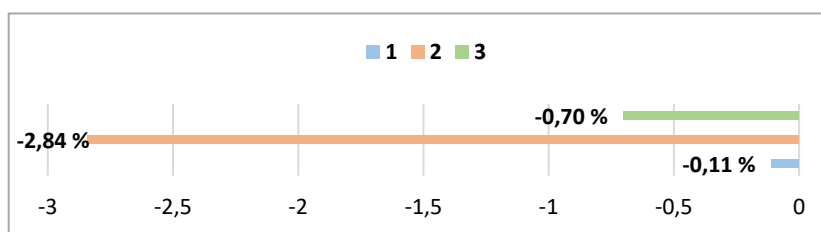


Figure 4 shows the variation of the company's electricity, water and fuel (gasoline and diesel) consumption in 2018 compared to 2017. In 2018, the consumption of electricity was at the same level as the year before. Total fuel consumption drastically reduced in recent years, both due to replacement of the corporate fleet with diesel vehicles new technology, as well as the use of pumps heat for the heating system. Finally, water consumption decreased slightly in 2018 compared to 2017.

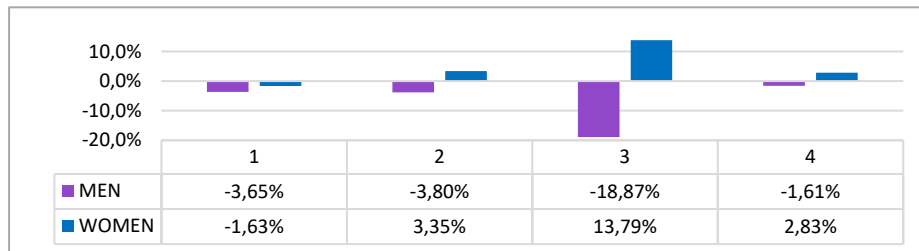
Social Perspective

In 2018, the company had 1,166 employees, working in operation and maintenance of Attiki Odos motorway and in toll stations, which means an increase of 0.69% compared to 2017. Figure 5 shows the variation (%) of the company employees' age distribution in 2018 compared to 2017. Overall, female employees increased by 2.83 % in 2018 compared to the previous year, in contrast to male employees who decreased by 1.6 %. Male employees decreased in all age groups and specifically 3.65 % in the age group under 30 years, 3.80 % in the age group 30 to 50 years and -18.90

% in the age group over 50 years. Regarding female employees, they decreased only in the age group under 30 years by 1.60 %, while they increased in the other age groups, with the largest increase in the age group over 50 years (13.80 %).

Figure 5. Company employees' variation (%) of age distribution (2018/2017)

Source: Attiki Odos, Corporate Responsibility Report 2018



CONCLUSIONS

The transport sector is large, diverse and complex, and infrastructure decisions and investments have an especially long lifespan (United Nations, 2016). Regardless of size and industry, all companies can contribute to the achievement of the SDGs by carrying out business in a responsible manner, while pursuing opportunities to address societal and environmental challenges through innovation and collaboration. Global challenges – ranging from climate change, water and food crises, to poverty, conflict and inequality – drive the transformation of business models and the embedding of globally acknowledged values in everyday business (Dimitriou et. al, 2020). Hence, the 17 Sustainable Development Goals can be directly correlated with business activities. In Greece, two of the largest operation and management companies in the transport sector meet their harmonization with these targets. Hence, an overview of how corporate actions can be best configured to promote responsible and sustainable business strategies is a major challenge for planners, managers and decision makers.

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Session 19:
Multiple Criteria Decision Analysis
chair: Evangelos Grigoroudis

A Multi-Criteria Methodology for Market Segmentation based on the Analysis of Consumer Choice Criteria

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Abstract

The proper market segmentation is a key problem in marketing with great impact on the success of importing a product or service into a market segment. Multi-criteria decision analysis contributes to solving the problem of market segmentation through the analysis of criteria on the basis of which the consumer/customer (decision maker) expresses his preferences when purchasing a product or service. The multi-criteria MARKEK methodology includes a phase that concerns the segmentation of the market based on the analysis of the criteria.

The aim of this work is the development of a methodology that will improve the proposed by the Multi Criteria Decision Support System MARKEK methodology (Matsatsinis and Samaras, 2000), by expanding the criteria analysis, adding a second layer of examination that will allow the further extraction of information from the same data and the deeper understanding of the competition between the products/services and their weak and strong points in reference to the criteria. The more in-depth analysis of the criteria obtained by the addition of a clustering algorithm, the Negotiable Alternative Identifier (NAI) algorithm and the Importance-Performance Analysis (IPA). Through this expansion of the analysis, the criteria that constitute the basis for the market segmentation will be determined with more precision and lead to a more detailed and accurate market segmentation.

KEYWORDS

Multi-criteria decision analysis, Decision Support Systems, Clustering, Market Segmentation, Marketing, Importance-Performance Analysis

INTRODUCTION

In this project we are presenting a methodology that will expand the criteria analysis implemented via the use of the MCDSS MARKEK (Matsatsinis and Siskos, 1999; 2003), a multi-criteria decision support system, which will provide more information on the product competition as well as the strengths and weaknesses of the products in regards to the criteria. Through the addition of this second layer of analysis, the criteria that will form the base for a higher precision market segmentation are determined. The goal of the development of this new methodology is to better support decision-makers by giving them a more detailed understanding of the market's status, the relation between the substitute products and the criteria that determine their market share, in order to assist the development of a new product and the marketing process for its introduction to the market. The methodology needs to give outputs that are easily understood and applied so that the decision-maker can make an educated decision on the company's future marketing strategy with lower risks.

METHODOLOGY

Based on the MARKEX methodology, we apply UTASTAR (Matsatsinis and Siskos 2003; Siskos and Yannacopoulos, 1985) to the multi-criteria tables of each consumer separately. The results we get are the weights (importance) of the criteria, the marginal and global utilities of each alternative (product) for each consumer. In this methodology there are two levels of analysis. In the first level the importance of each criterion is showcased for every product of interest separately and in the second level, the products are compared on the importance of the criteria, with each criterion examined separately.

The application of the methodology requires the separation of the products (Baourakis, Matsatsinis and Siskos, 1996; 2001) into two groups/clusters, an action that in this article, is completed with the use of a clustering algorithm and the NAI algorithm (Yen, 1999). A new comparable value, u_i' , is calculated for all criteria under each product in both groups (Cluster 1, Cluster 2) based on their utility to make the comparison between them possible.

Categorizing the criteria based on how they influence the consumers' ranking of the product

In the first level of the analysis two groups/clusters are created based on the utilities and the significant preference towards each product by the consumers, with the use of a clustering algorithm and the NAI algorithm. The first group (Cluster 1) includes the cases in which the products hold high utility and are positively differentiated from other products by each consumer. The second group (Cluster 2) includes all the cases that don't qualify for the first group, in which the products hold low utility for the consumers. After the formation of the two clusters, the sum of the values each criterion holds, and their average, is calculated for every product in both clusters and used in the formula:

$$u_i' = \frac{u_i - \bar{u}}{\sqrt{\sum(u_i - \bar{u})^2}} \quad (2.1)$$

where,

u_i' : the new comparable value of each criterion,

u_i : the sum of the utilities of each criterion, and

\bar{u} : the average of the sums of the utilities of each segment,

to calculate a new set of values for each product in Cluster 1 and Cluster 2. The new values are paired and displayed on a graph. The vertical and horizontal axes are defined [-1, 1] with the vertical axis standing for the new comparable values of the criteria in Team 1 while the horizontal axis for the new comparable values of the criteria in Team 2. The importance of the criteria of each product is conveyed through the use of the "Importance-Performance Analysis" (Martilla and James, 1977).

Application

Applying the above in the case of a product (Hediard) we obtain the following results (Table 1; 2).

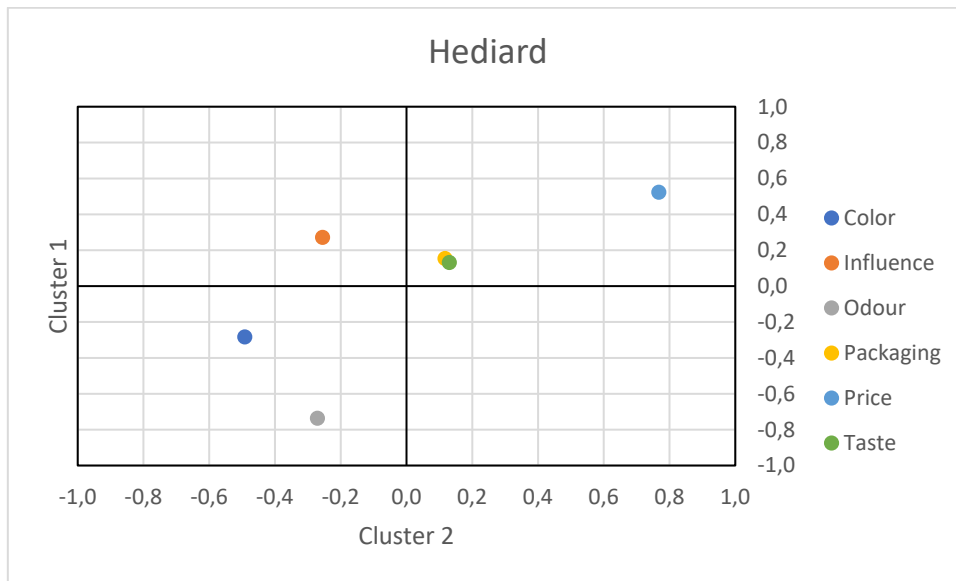
Table 1. Cluster 1 - Hediard Utilities

CLUSTER 1: HEDIARD UTILITIES							
	Colour	Influence	Odour	Packaging	Price	Taste	\bar{u}
u_i	4.21708	5.41975	3.23417	5.16456	5.96627	4.99816	4.83333
u_i'	-0.28421	0.27046	-0.73753	0.15276	0.52251	0.07602	

Table 2. Cluster 2 - Hediard Utilities

CLUSTER 2: HEDIARD UTILITIES							
	Colour	Influence	Odour	Packaging	Price	Taste	\bar{u}
u_i	9.97909	11.59494	11.48593	14.13590	18.57666	14.22747	13.33333
u_i'	-0.49125	-0.25460	-0.27056	0.11754	0.76791	0.13095	

Figure 1. Hediard New Comparable Criteria Values



The graph displays the importance of all the criteria for the product Hediard in an IPA diagram makes the intake of the information quick and easy. In this example Influence is the criterion that has the most positive impact on the consumers’ preference. It can also be observed that the Price criterion has a positive impact on both Clusters while the Color criterion accordingly has a negative impact.

Categorizing the products by consumers’ behavior

In the second level of the analysis the size of the two teams is equalized to make it possible to compare between different products. The smallest group of entries formed among the products by the two algorithms is used as reference for the largest size the new same sized Clusters can be. In this process some cases must be excluded. The decision on which consumers will be included in the new groups of Cluster 1 and Cluster 2 is made by using a criterion as reference and keeping the ones with the highest utility values in the criterion of choice. Once the same sized Clusters are formed, the sum of each criterion and their average for each product in both Clusters is calculated and used in the formula (2.1) to calculate a new set of values for each product in Cluster 1 and Cluster 2. This time the paired values for each product are showcased in graphs for all criteria separately.

Example using Packaging as the referenced criterion:

Applying the above in the case of a product (Hediard) we obtain the following results (Table 3 and 4).

Table 3. Team 1, Utilities Sum New Values – Reference Criterion Packaging

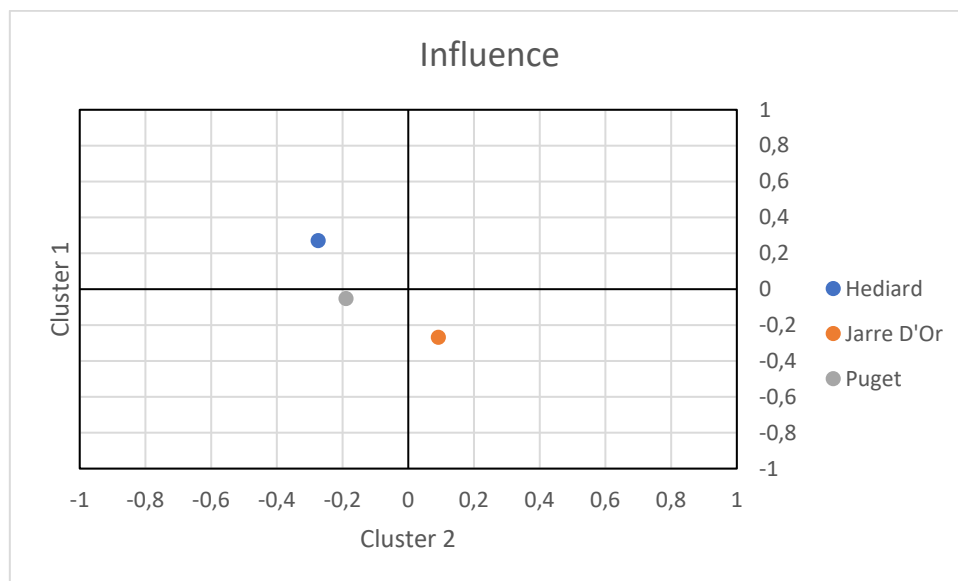
Reference Criterion - Packaging: Cluster 1 Sums - New Values						
	Colour A'	Influence A'	Odour A'	Packaging A'	Price A'	Taste A'
Hediard	-0.28421	0.270455	-0.73753	0.15276	0.522508	0.076019
Jarre D'Or	-0.33619	-0.26812	-0.41841	0.372815	0.705635	-0.05573
Puget	-0.40114	-0.05224	-0.55138	0.538179	0.491984	-0.02539

Table 4. Team 2, Utilities Sum New Values – Reference Criterion Packaging

Reference Criterion - Packaging: Team 2 Sums - New Values						
	Colour B'	Influence B'	Odour B'	Packaging B'	Price B'	Taste B'
Hediard	-0.29881	-0.27375	-0.37852	0.742388	0.348865	-0.14017
Jarre D'Or	-0.2655	0.092288	-0.51382	0.762661	0.152543	-0.22818
Puget	-0.22601	-0.18908	-0.41015	0.824534	0.180753	-0.18004

A graph is created for each criterion separately. The graph of the criterion Influence is used for demonstration purposes.

Figure 2. Influence New Values - Reference Criterion Packaging



The graph showcases the importance of the criterion Influence for the three products under examination. The display of the products on the graph enables the comparison between them. In this example Hediard is shown to receive a positive impact on the consumers' preference in regards to the criterion. In contrast, Jarre D'Or receives a negative impact. Finally, the consumer's preference for the product Puget is not influenced by this criterion.

CONCLUSIONS

The results of this project are positive. The goal was to introduce a methodology that would expand the criteria analysis implemented via the use of the MCDSS MARKEK (Matsatsinis and Siskos, 1999; 2003), a multi-criteria decision support system, and provide more information on the product competition as well as the strengths and weaknesses of the products in regards to the criteria. In the future the research and analysis of the results will continue with additional methods.

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The ranking of the Air Traffic Controllers' competencies: an empirical survey

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Abstract

In a safety-critical domain, like air traffic control (ATC), the human factor plays a vital role. For this reason, personnel undergoes continuous training and is evaluated on various competencies according international standards, among them a set of competencies related with the social and cognitive side of Air-Traffic Controllers (ATCOs). In the current paper we examine the significance of the whole set of the competencies in the air traffic control in cooperation with experts in the field by using two approaches for the ranking order, a descriptive statistics approach (means-based rank) and a multi-criteria method (PROMETHEE-based rank). Ten trainers high-level military officers acting as ATCOs, responsible for many Greek aerodromes supporting military and commercial aviation traffic, shared their experience with us. The results confirm that situation awareness is the most important competence while the self-management and continuous development is the less important one. In addition, the results show that competencies are classified into three groups with respect to their significance, the "more" and the "less" important and an intermediate group.

KEYWORDS

Air traffic control, air traffic control management, competencies, multi-criteria decision making.

INTRODUCTION

In various working environments competencies are considered as vital, in the sense that either they distinguish applicants for a job position or they are necessary for a successful career or they are considered as causal factors in safety-related systems. Competencies of Air Traffic Controllers (ATCOs) are defined as the attitudes and behaviours not directly related to the air traffic control, the control systems and standard operation procedures. These competencies cover the social and cognitive side of the ATCO.

Air traffic control services at Greek aerodromes are provided by civilian and military ATCOs, though there are some aerodromes which serve only civil or only military or both military and civil traffic. Our empirical evidence in Greek aerodromes supporting both military and civil traffic or just military traffic, shows that at least one air traffic controller per shift must have the competency of *situation awareness* at the highest level, irrespective of other team-members' level. This diversity level in *situation awareness* for coping with high pressure, heavy workload and uncertain situations, does not indicate failure in safety training; rather it may indicate personal characteristics or the ATCOs' level of experience. This empirical rule in the formation of daily shifts by ATC directors motivated us to investigate the significance of ATCOs competencies in aerodromes with the above mentioned characteristics.

For the purpose of the current study 10 high skilled ATCOs trainers (henceforth referred to as "experts"), were interviewed in order to express their opinion about the significance of competencies. The scenario given to the experts is based on a shift of Air Traffic Controllers in which the last are required to manage mixed traffic (military and civil aircraft). The ATCO shift consists of four persons performing different tasks, as follows: the ATCO supervisor, the AD (Aerodrome) controller, the Ground Controller and the Assistant AD controller. Usually, experts assess the performance of the AD controller in normal situations, although in the specific scenario the experts have to take into consideration that the AD controller is required to manage an aircraft in an emergency situation (landing with failure on one of two engines). The experts were asked to write down the weights of the AD controller competencies describing their relative importance, explicitly, for the above scenario. Subsequently, two different approaches were applied, which all confirmed that *situation awareness* is the most important competency. More specific, the expressed weights are transformed into ranking orders, by using two approaches: (a) the means-based ranking, and (b) the PROMETHEE method (Brans et al. 1984; Macharis et al. 1998; Brans and Smet 2016). It was obvious from the early beginning that the experts considered *situation awareness* as the most important competency in the effective handling of the emergency situation, as this is the main criterion that defines the formation of ATCOs' groups at the Greek aerodromes. Therefore, the research question of the current study is reformulated focusing on the competencies that follow *situation awareness* as additional important factors. In this sense, the current paper is organised as follows: the 2nd section presents briefly the competencies as they are proposed by Eurocontrol (2015). Subsequently, the 3rd section presents the research study and the ranking results of competencies by using two different approaches (means-based and

PROMETHEE), along with a comparison of the obtained results. Finally, some concluding remarks are discussed in the last section.

AIR TRAFFIC CONTROLLERS' COMPETENCIES

The current work is based on the recommendations of the Eurocontrol (EC) "ATC Refresher Training Manual" for the evaluation of ATCOs' competencies. The EC recommendations include 10 competencies, as follows: (i) *Situation awareness – SA*, (ii) *Traffic and capacity management – TRAF*, (iii) *Separation and conflict resolution – SEPC*, (iv) *Communication – COMM*, (v) *Coordination – CORD*, (vi) *Management of non-routine situations – NONR*, (vii) *Problem solving and decision-making – PROB*, (viii) *Self-management and continuous development – SELF*, (ix) *Workload management – WORK*, and (x) *Teamwork – TEAM*.

RESEARCH STUDY & RESULTS

The current research study follows two stages. In the first stage, the preference elicitation stage, 10 high skilled ATCOs trainers (henceforth referred to as "experts")³, were interviewed in order to express their opinion about the significance of competencies for a given scenario. The scenario given to the experts is based on a shift of ATCOs in which they manage mixed traffic (military and civil aircraft). There are four ATCOs in each shift, performing different tasks as follows: the ATCO supervisor, the AD (Aerodrome) controller, the ground controller and the assistant AD controller. The experts were asked to write down the weights of the competencies describing their relative importance, explicitly. The relative importance of the competencies is then transformed into "initial" rankings. Since, one compromise ranking of the competencies is necessary, the "initial" rankings are the input data for the next stage (the exploration stage), which aims at the formulation of a single ranking order of the competencies. To this end, two approaches are employed: (a) the means-based ranking that takes into consideration the mean weights of each competency and (b) the PROMETHEE method (Brans et al. 1984; Macharis et al. 1998; Brans and Smet 2016). The resulting ranking order may indicate the following: (a) the most and the least important competency of a specific situation in the working field of an aerodrome that the air traffic services provided by the military ATCOs, (b) competencies of the same importance, (c) competencies which are ranked differently depending of the aggregation methods applied, and (d) a classification scheme of competencies into groups.

The preference elicitation stage

The study was performed in air traffic control units of specific Greek aerodromes that rely on military ATCOs. The experts were asked to work individually on the given scenario and to fill-in the weight significance (relative importance) for each competency, taking into account that the weights should sum up to 100. All of them replied without expressing any difficulty, and their individual judgements are presented in Table 1 (A1 to A10: ten experts). The first indications from Table 1 show that every expert recognizes SA as the most important competency for the AD controller. Beyond SA, *Communication* (COMM) is considered as the second most important competency by most experts (8 out of 10); an exception is the opinion of experts A7 and A9. The next observation regards the weighting scheme followed by experts. It looks like the experts consider the last part of competencies as less important, as this is obvious from the weights in the last rows of Table 1.

Another observation from Table 1 deals with the several cases where the experts assigned the same weights for different competencies. For example, expert A1 assigns a 12% weight for NONR and PROB, a 10% weight for TRAF, SEPC and COMM, and a 8% weight for SELF, WORK and TEAM. This condition is observed for all experts.

Table 1. Explicitly expressed weights (%) by ten experts

COMPETENCIES	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
1.Situation Awareness (SA)	14	17	20	15	25	19	19	15	17	21
2.Traffic and capacity management (TRAF)	10	11	10	9	10	10	12	11	12	10
3.Separation and conflict resolution (SEPC)	10	11	10	9	10	10	12	11	12	10

³ The considered ATCOs are high-level military air traffic officers as experts in the field, responsible in the working environment for various Greek aerodromes, those with military and civil or just military traffic.

4.Communication (COMM)	10	14	12	12	12	12	10	14	8	12
5.Coordination (CORD)	8	11	12	12	12	12	10	14	8	12
6.Management of non-routine situations (NONR)	12	8	10	10	7	8	7	8	10	8
7.Problem solving and decision-making (PROB)	12	9	7	10	7	9	7	8	10	8
8.Self-management and continuous development (SELF)	8	6	5	7	5	6	5	5	7	5
9.Workload management (WORK)	8	7	7	8	6	6	9	7	8	7
10.Teamwork (TEAM)	8	6	7	8	6	8	9	7	8	7
	100	100	100	100	100	100	100	100	100	100

The exploration stage

In the exploration stage we focus on the weights (relative importance) as they are externally expressed by each expert, in order to derive a “consensus” ranking of the competencies combining the inputs provided by all experts. The analysis is based on two approaches. The first approach is based on descriptive statistics (means-based) and the second on the PROMETHEE multi-criteria method (Brans et al., 1984; Macharis et al. 1998; Brans and Smet, 2016). It should be noted that the means-based approach is a simple average of the respondents’ judgments that does not consider the interrelationships between the competencies. On the other hand, the PROMETHEE method provides set-dependent evaluations, which implicitly consider the dependences between the competencies. In that regard, the evaluation of a competency’s importance through these approaches does not only consider the judgments of the experts of about the specific competency under examination, but also the judgments about all competencies in the analysis.

Means-based rank

According to the first approach, the descriptive statistics of Table 2 indicate that there are different judgements for each competency. In conclusion, if the mean values are considered as an indication of the criteria’s significance, then SA is the most important competency, while SELF the least important. However, the mean weights are in several cases almost equal, which indicate that further consideration is needed, as demonstrated in the following sub-sections.

Table 2. Descriptive statistics – Means-based rank

	Max	Min	Means	Standard deviation	Rank
SA	25	14	18.2	3.33	1
TRAF	12	9	10.5	0.97	4
SEPC	12	9	10.5	0.97	4
COMM	14	8	11.6	1.84	2
CORD	14	8	11.1	1.91	3
NONR	12	7	8.8	1.62	5
PROB	12	7	8.7	1.64	6
SELF	8	5	5.9	1.10	9
WORK	9	6	7.3	0.95	8
TEAM	9	6	7.4	0.97	7

PROMETHEE-based rank

By assuming that all experts' opinions are equally weighted, the final results for the ranking of the competencies are presented in the last column of Table 3. The net flow, ranges from +9 for the most important competency (a competency considered, by all experts, as strictly more important than others) to -9 for the least important one (a competency considered, by all experts, as strictly less important than others).

Table 3. Promethee-method based ranking

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	Net flow	Rank
SA	1	1	1	1	1	1	1	1	1	1	9	1
TRAF	3	3	3	4	3	3	2	3	2	3	2.5	3
SEPC	3	3	3	4	3	3	2	3	2	3	2.5	3
COMM	3	2	2	2	2	2	3	2	4	2	5.2	2
CORD	4	3	2	2	2	2	3	2	4	2	2.3	4
NONR	2	5	3	3	4	5	5	4	3	4	-1.1	6
PROB	2	4	4	3	4	4	5	4	3	4	-0.5	5
SELF	4	7	5	6	6	6	6	6	5	6	-8.6	9
WORK	4	6	4	5	5	6	4	5	4	5	-5.7	8
TEAM	4	7	4	5	5	5	4	5	4	5	-5.6	7

<i>Weight</i>	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
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Thus, the PROMETHEE-based results indicate, once more, the superiority of SA for the specific scenario. The competency that follows in the 2nd place is COMM, and then TRAF and SEPC follow in the 3rd place, CORD in the 4th place, and so on, while the least important competency is SELF. Following this ranking approach we observe some differences in comparison with the previously calculated ranking orders. These differences are discussed in detail in the next subsection.

Comparison of the results

The results of the two analyses are summarized in Table 4. In conclusion, the applied approaches indicated the same ranking order for the following five competencies in the given situation: SA (1st), COMM (2nd), TEAM (7th), WORK (8th) and SELF (9th). For the other five competencies (TRAF, SEPC, CORD, NONR and PROB), the ranking orders are similar. The comparison of results indicated, also, a subset of "more" important competencies and a subset of "less" important competencies, as well as an intermediate group of competencies, despite all of them being considered necessary in the working environment of air traffic control.

Overall, it is evident by the results that competencies are not considered of equal importance in the given scenario for AD controllers. This is a valuable insight since the participating experts have expressed a realistic opinion of their beliefs and the ranking results confirm what we have initially observed in the formation of ATCOs shifts, where the SA level of the human factor is vital.

Table 4. Comparison of results

	Means-based ranking	PROMETHEE-based ranking
SA	1	1
TRAF	4	3
SEPC	4	3
COMM	2	2
CORD	3	4
NONR	5	6
PROB	6	5

SELF	9	9
WORK	8	8
TEAM	7	7

CONCLUSIONS

The current paper is motivated by the empirical observation that SA is a key-factor in the working environment of air traffic control. Thus, the research question is reformulated to which competencies follow SA and in which order, based on a given scenario. Firstly, the results indicated the agreement between experts on the significance of ATCOs competencies in the working environment of aerodromes, where the workflow is challenging and the situations are possible, as the results of the two applied approaches yielded similar rankings. The results indicated that SA is the most important competency for AD controllers, followed by COMM, whereas TEAM, WORK, and SELF are the least important ones. Secondly, the results indicated that competencies form three groups, the “more important competencies” (SA, TRAF, SEPC, COMM and CORD), the intermediate group of competencies (NONR and PROB) and the “less important competencies” (SELF, WORK and TEAM). Although, the experts’ opinions varied for the relative importance of the competencies, the applied ranking approaches have yielded a consensus ranking that describes the opinions of all experts, as well as a classification of the competencies into three groups. The ranking order and the classification of competencies may be valuable for the organization of training/retraining of ATCOs or for management purposes in a demanding working environment like the air traffic control. Additionally, the current research study indicated the ranking order of ATCOs competencies, which is based on the individual preferences and experiences of experts. This may be an indication that another set of experts may provide different ranking orders. Nevertheless, this study representing specific experts (more than 1/3 of them) indicates the way they act as directors, supervisors, trainers or evaluators in their everyday working life by considering SA and COMM as the most important competencies.

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Criteria for honey consumption in Greece: a MUSA application

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Abstract

The aim of this research is to investigate honey consumer preferences in Greece. The MUSA method (Multicriteria Satisfaction Analysis) is utilized to link the frequency of honey consumption with consumer attitudes towards honey. MUSA is an ordinal regression-based preference disaggregation method for measuring and analyzing customers' satisfaction in the area of multicriteria decision analysis. MUSA is used to estimate the contribution (importance) of consumers' attitudes towards honey to the frequency of honey's consumption. The survey took place at March 2019 in Thessaloniki where 471 properly answered questionnaires were collected. The criteria used were taste, safety, nutrition, health, environmental friendliness, trust towards producers, enhancement of local economy, environmental helpfulness, connection to Greek tradition, connection to Mediterranean Diet and connection to a nutritious diet. Criteria weights of the analysis showed that connection to Greek tradition, nutrition and taste are the attitudes with the strongest effect on honey consumption, while the criterion with the weakest effect is trust towards producers. Demanding indices of all criteria are negative, thus consumers are not strongly demanding regarding the selected variables. The attributes with the strongest performance are nutrition, health and taste while the overall average performance of honey consumption frequency obtains a high score as well. Results suggest that Greek consumers are strongly affected by tradition, culture and health issues when purchasing honey while sensory attributes (taste) are also important.

KEYWORDS

honey consumption, Greek consumers, consumer behavior, MUSA, multi-criteria analysis, operational research

INTRODUCTION

Greece is a country positioned in the armpit of Mediterranean Sea, critically suitable for apiculture which gains a competitive advantage due to this geographical position and its diversified flora (Dimou et al., 2014). Research into honey's consumption is critical for Greek apiculture which is economically affecting more than 20,000 families including non-professional beekeepers (Dimou et al., 2014). Furthermore, professional apiculture is quite advanced and occupies the 6th position in European Union considering annual honey production (European Commission, 2018).

Consumers' behavior towards honey has been examined at a variety of countries. In Ireland consumers base their honey's consumption preferences on price, texture (thickness), color (dark golden), production scale (small producer) and package (Murphy et al., 2000). In Italy consumer consider geographical origin as the main factor for honey's purchase while price, organic attribute, productions' landscape and crystallization are following (Cosmina et al., 2016). Italian consumers' willingness to pay is affected by organic attribute and more liquid honey (Cosmina et al., 2016). American consumers' willingness to pay is affected by honey's local and national origin compared with those of international honey, positive information about local honey and negative about international honey on label and jar style (Wu et al., 2015). Honey's consumption in Croatia relies heavily on its health attributes (Bršćić et al., 2017). In Romania medical benefits, dietary quality and lifestyle were primary motivators together with honey intrinsic attributes like local origin, taste, aroma, color and thickness (Arvanitoyannis & Krystallis, 2006; Krystallis et al., 2007). In Hungary, both intrinsic, quality and type of honey, and extrinsic, price and package, attributes are important for consumers (Ványi et al., 2011). Furthermore, knowing the name of the producer was also important for older people (Ványi et al., 2011). The most important honey's intrinsic attributes for Australian consumers are taste and flavor while the most important extrinsic characteristic is innovative packaging (Batt & Liu, 2010). Congolese consumers prefer certain types of honey, like savannah honey (Gyau et al., 2014). Saudi Arabian consumers prefer local honey and retailers at open markets (Ismail et al., 2014).

The scope of this paper is utilized to link the frequency of honey consumption with consumer attitudes towards honey. In order to achieve this, Multicriteria Satisfaction Analysis (MUSA) is used. MUSA method is an ordinal regression-based

preference disaggregation method for measuring and analyzing customers' satisfaction in the area of multicriteria decision analysis. MUSA will be used to estimate the contribution (importance) of consumers' attitudes towards honey to the frequency of honey's consumption.

METHODOLOGY

In order to answer the research purpose, which is to investigate the link between the frequency of honey's consumption with consumers' attitudes towards honey, Multicriteria Satisfaction Analysis (MUSA) method was utilized. MUSA method was developed by Grigoroudis and Siskos (2002) as an ordinal regression-based preference disaggregation multicriteria decision analysis method that measures and analyzes customers' satisfaction. It has been used for investigating costumers' satisfaction, employee's satisfaction, web users' satisfaction etc. (Grigoroudis et al., 2008; Grigoroudis & Siskos, 2003; Manolitzas et al., 2014; Mihelis et al., 2001; Siskos et al., 1998).

In order to answer this research question at January 2019 a structured questionnaire was designed, while data were collected at February 2019. The questionnaire was structured in three parts. For this paper part two, that obtained five-point likert scale questions about honey's consumption, and part three, that obtained demographic questions, were used. Convenience sampling technique was used in two Greek administrative regions: Central Macedonia (mainly at the city of Thessaloniki) and Thessaly (mainly at the city of Karditsa). The total sample is consisted of 471 answers.

MUSA assumes a collective value function Y^* for the dependent variable and a set of functions X_i^* for the independent variables. Maximum consistency should be achieved between the functions of the dependent and independent variables. The set of X_i^* functions are referring to consumers' attitudes towards honey, while function Y^* to the frequency of honey's consumption. A double-error variable will be introduced to the ordinal regression equation:

$$\hat{Y}^* = \sum_{i=1}^n b_i X_i^* - \sigma^+ + \sigma^- \quad (1)$$

\hat{Y}^* stands for the estimation of the global value function (Y^*), n stands for the number of criteria, b_i stands for the weight of the i -th criterion, while σ^+ and σ^- stand for overestimation and underestimation errors, respectively. $\sum_{i=1}^n b_i$ (sum of weights) is equal to one. Y^* and X_i^* , which stand for, global and partial functions, are monotonous and normalized in the interval [0,100]. In order to assure monotonicity, the following transformation equations are used:

$$z_m = y^{*m+1} - y^{*m} \quad m = 1, 2, \dots, \alpha - 1 \quad (2)$$

$$w_{ik} = b_i x_i^{*k+1} - b_i x_i^{*k} \quad k = 1, 2, \dots, \alpha_i - 1 \quad \text{and} \quad i = 1, 2, \dots, n \quad (3)$$

Where α and α_i stand for the number of levels of global and partial functions Y^* and X_i^* , x_i^k stands for the level of criterion i ($k = 1, 2, \dots, \alpha_i$) and x_i^{*k} stands for the value of x_i^k , y^{*m} stands for the m level of total satisfaction ($m = 1, 2, \dots, \alpha$) and y^m stands for the satisfaction level.

The basic equation will be re-written as a linear-programming problem:

$$[min]F = \sum_{j=1}^M \sigma_j^+ + \sigma_j^- \quad (4)$$

which is subject to:

$$\sum_{i=1}^n \sum_{k=1}^{x_i^j-1} w_{ik} - \sum_{m=1}^{y^j-1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \text{for} \quad j = 1, 2, \dots, M \quad (5)$$

$$\sum_{m=1}^{\alpha-1} z_m = 100 \quad (6)$$

$$\sum_{i=1}^n \sum_{k=1}^{\alpha_i-1} w_{ik} = 100 \quad (7)$$

$$z_m, w_{ik}, \sigma_j^+, \sigma_j^- \forall m, i, j, k \quad (8)$$

M stands for the size of the sample, x_i^j , y^j stand for the level in which X_i and Y are estimated (j -th level).

Post optimality analysis is used to solve the problem of model stability. The constraints of the LP equation are producing the polyhedron of multiple or near optimal solutions. In order to get the final solution, MUSA performs n linear programs with the following form:

$$[max]F' = \sum_{k=1}^{\alpha_i-1} w_{ik} \quad \text{for} \quad i = 1, 2, \dots, n \quad (9)$$

which is subject to the following constraints:

$$F \leq F^* + \varepsilon \quad (10)$$

and all constraints (5), (6), (7), (8)

The average of solutions given by the performance of of n LPs is the final solution. At LP equation (9), ε is a small percentage of F^* . When there is a strong stability the solution is more representative.

MUSA also generates global and partial performance indices which stand for the performance of frequency of honey's consumption and the performance of each criterion accordingly, and demanding indices which stand for the demanding levels of customers for each criterion. Performance indices and demanding indices are given by the following equations are used:

$$\text{Global Satisfaction Index: } S = \frac{1}{100} \sum_{m=1}^a p^m y^{*m}$$

$$\text{Partial Performance Index: } S_i = \frac{1}{100} \sum_{k=1}^{a_i} p_i^k x_i^{*k}$$

$$\text{Overall Demanding Index: } D = \frac{\sum_{m=1}^{a-1} (\frac{100(m-1)}{a-1} - y^{*m})}{100 \sum_{m=1}^{a-1} \frac{m-1}{a-1}} \quad \text{for } a > 2$$

$$\text{Partial Demanding Index: } D_i = \frac{\sum_{k=1}^{a_i-1} (\frac{100(m-1)}{a_i-1} - x_i^{*k})}{100 \sum_{k=1}^{a_i-1} \frac{k-1}{a_i-1}} \quad \text{for } a > 2 \text{ and } i = 1, 2, \dots, n$$

The percentage of customers that belong to level of satisfaction y^m and criterion level x_i^k are represented by p^m and p_i^k , respectively.

Both the dependent variable (frequency of honey's consumption) and the independent variables (attitudes towards honey) were measured at five-point likert scales.

The criteria used were 1) Taste, 2) Safety, 3) Nutrition, 4) Health, 5) Environmental friendliness, 6) Trust towards producers, 7) Enhancement of local economy, 8) Environmental helpfulness, 9) Connection to Greek tradition, 10) Connection to Mediterranean Diet and 11) Connection to a nutritious diet.

RESULTS

The total sample consists of 471 respondents. There is a slight greater percentage on females (56.4%) considering gender variable. Most of the respondents obtain a university degree (75.6%). Private employees are the biggest occupation category (33.9%), followed by public employees (28%), students (16.7%), businessmen/businesswomen (10.2%), pensioners (6.1%) and unemployed people (4.4%).

Results from MUSA are presented at Table 1. The performance index of frequency of honey consumption is 88.42%, indicating that Greek consumers are frequently consuming honey. The greatest performance indices are obtained by Nutrition, Health and Taste, while the least strong performance indices are obtained by Trust towards producers. The greatest weights are obtained by Connection to Greek tradition, Nutrition and Taste, while the least strong performance indices are obtained by Trust towards the producers, Enhancement to Greek economy and environmental friendliness. Consequently, the criterion with the greatest importance (weight) for honey is Connection to Greek tradition followed by Nutrition and Taste. Every demanding index is negative, thus, Greek consumers obtain low medium demanding level towards honey regarding the selected attributes.

Table 1. MUSA results

Criteria	Weight (%)	Performance Index	Demanding Index
Taste	9.92	93.66	-40.1
Safety	7.75	89.31	-48.39
Nutrition	12.81	96.51	-67.87
Health	7.75	94.87	-48.39
Environmental friendliness	6.84	88.57	-33.57
Trust towards producers	5.77	71.87	-30.72
Environmental helpfulness	7.75	88.27	-48.39
Connection to Greek tradition	18.5	92.19	-78.37
Connection to Mediterranean Diet	7.75	90.68	-48.39

Connection to nutritious diet	9.09	91.01	-54.86
Enhancement to Greek economy	6.02	89.93	-33.6
Overall satisfaction		88.42	-60

Source: Authors' research

CONCLUSIONS

This study analyzes Greek consumers' attitudes towards honey according to their importance for the frequency of honey's consumption. Honey is mostly regarded as nutritious, healthy and tasty. Generally, Greek consumers are frequently consuming honey. The strongest influence to the frequency of honey's consumption is obtained by Connection to Greek tradition followed by Nutrition and Taste, revealing that honey's consumption has a cultural, a health-related and a sensory dimension. The smallest influence to the frequency of honey's consumption is obtained by Trust towards the producers, Enhancement to Greek economy and environmental friendliness, revealing that honey's consumption is less associated with consumer national or environmental awareness and connection between producers and consumers.

Thus, tradition is the major motivator for honey consumption. Tradition strongly associated with foods' consumption and modern marketing utilizes both concepts (Bryla, 2015). Tradition, as a social construct, affects the marketing mix as part of the non-material symbolic dimension of Product (Becut, 2011). Taste and Health are parts of the material dimension of Product. Both, material and non-material dimensions of Product, with regards to honey marketing mix are important.

This research's contributions are both academic and managerial. Consumer behavior towards honey, as part of food products marketing, has been a field with a variety of studies. This study utilizes MUSA method in order to rank the criteria for honey's consumption. Furthermore, as far as the authors are concerned, it is the first study utilizing this methodology (MUSA) for honey's consumption. The managerial implications of this study are related to the importance of honey's attributes. Beekeepers, honey distributors and honey packaging manufacturers can benefit from these results by integrating them in their marketing mix. Regarding the Product part of 4 Ps, managers should pay attention both to the material and the non-material dimensions. Regarding the non-material dimension, honey's connection to Greek tradition should be communicated to consumers. Regarding the material dimension, healthiness of honey should be communicated to the consumers and each manufacturer and beekeeper should ensure that their honey meets the taste standards of their clients.

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The Effects of Customers' Satisfaction on Business Profitability in Greece's Banking Sector. An Empirical Study

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Abstract

Over the last few decades, the linkage between customers' satisfaction and business profitability is proven a very important factor in modern business organizations. According to many researchers' customers' satisfaction is strongly correlated to business profitability. Besides, several research efforts studied this linkage in order to determine the extend of effecting customers' satisfaction on business profitability. Thus, customers' satisfaction has gained vivid interest of scholars worldwide. Business profitability can be determined by customers' loyalty and an increasing market share. Besides, the banking sector at both international and national levels is currently appreciated as one of the most dynamic and competitive industries. The aim of this research is to investigate the relationship between business profitability and customers' satisfaction in the Greek banking sector. The analysis of the customers' satisfaction was based on the multicriteria MUSA (Multicriteria Satisfaction Analysis) method. MUSA is an ordinal regression model which is based on the principles of multicriteria decision analysis. MUSA method is part of the wider category of aggregation – disaggregation approach, being based on the principles of qualitative analysis regression. Data were collected through a web site questionnaire that was been delivered in order to better understand the customers' views on the service overall as well as their satisfaction levels on particular aspects of the service. The relationship between business profitability and customer satisfaction results has been analysed using correlation coefficients and regression models. The research findings unveiled a positive correlation between customers' satisfaction and bank profitability.

KEYWORDS:

Customer satisfaction, Banking Sector, Profitability, Multicriteria Analysis, MUSA Methodology

INTRODUCTION

In recent years the concept of customer satisfaction has gained vivid attention from companies regardless of the business sector in which they operate. Many companies are perceiving customer satisfaction as an indicator to measure the marketable performance of their products or services. Companies put more effort not only to maintain but also to increase their market share by satisfied customers. On the other hand, an equally important concept for modern enterprises or organizations is business performance. In this context, national or international companies develop and use effective tools and methods to measure both the quality of their services and products, as well as the satisfaction of their external and internal customers. Many surveys attempted to link customer satisfaction with business performance such as loyalty, productivity, profitability, reputation, market share, stock performance, and financial results. (Golovkova et al., 2019; Fornell et al., 2016; Eklof et al., 2017; Kasiri et al., 2017; Lee et al., 2017). High business performance is directly linked to satisfied customers, a fact that it is supported by both management theorists and senior business executives (Heskett et al., 1997; Peters and Waterman, 1982; Otto et al., 2020; Sorescu and Sorescu, 2016; Cuevas-Vargas et al., 2019). Besides, in recent years the banking sector is considered one of the most important sectors of the Greek economy since it contributes to the national income growth, the increase of government revenue, and the creation of new jobs. The scope of this study is to analyse the relationship between customer satisfaction and profitability using data from the banking sector in Greece (Konstantakis et al., 2020; Koutsothanassi et al., 2017)

THE RELATIONSHIP BETWEEN CUSTOMER SATISFACTION AND BUSINESS PROFITABILITY

Customer satisfaction is one of the key concepts in strategic marketing. Academicians, practitioners and businessmen acknowledge the importance of customer satisfaction for firms' development and profitability. Moreover, satisfied customers tend to demonstrate loyal behaviour (Fornell, 1992; Anderson & Sullivan, 1993). Literature at both marketing management and service management unveils that customer satisfaction certainly influences customer profitability. In parallel, quality and customer satisfaction are proven key drivers of businesses' financial performance. Within the last decade there is empirical evidence that confirms the positive association or negative affinity developed between customer satisfaction and business profitability. Numerous studies have been conducted to investigate such a relationship between customer satisfaction and business profitability at an entrepreneurial environment that includes a plethora of affectionate factors. Subsequently, numerous empirical studies confirmed contradicting results of either positive or negative relationship between customer satisfaction and companies' profits. Relevant research confirmed the existence of a positive correlation between customer satisfaction and profitability (Grönroos, 1990; Bernhardt et al., 2000; Heskett et al., 1994; Zenios and Soteriou, 1997; Steven et al., 2012; Hallowell, 1996; Banker and Mashruwala, 2007, Anderson et al., 1997; Drosos et al., 2019), as well as a negative correlation between the aforementioned factors (Tornow and Wiley, 1991; Wiley, 1991; Schneider, 1991; Bernhardt et al., 2000).

MATERIALS AND METHODS

For the purpose of this study the findings of four consecutive six-month long surveys were presented, while measuring the satisfaction levels of customers of four Greek banks. For the collection of the data a web-sited questionnaire was used in order to better record the customers' views on the service experienced, as well as their satisfaction levels on particular aspects of service. Final input data consisted of 5.500 questionnaires. It is denoted that the set of satisfaction criteria in the survey was based on bibliographical research (Michelis et al., 2001; Grigoroudis and Siskos, 2010; Drosos and Tsotsolas, 2014; Chalikias et al., 2016; Skordoulis et al., 2017; Drosos et al., 2018; Drosos et al., 2019; Drosos et al., 2020). The introduced questionnaires measured the customer satisfaction in several differentiated sectors. The main satisfaction criteria for the survey consists of: 1) Products - Services: Satisfaction from the services and products of each one bank surveyed, 2) Stores: Location of stores and the network of bank branches, 3) Human Resources: Satisfaction gained by a client when communicating with the banks' staff surveyed, 4) Customer service: Consumer satisfaction from the service offered. Furthermore, secondary data concerning Indices by the bank firms were collected in order to examine the relationship between bank firms and customer satisfaction. These Indices are shown in Table 1.

Table 1: Profitability Indexes

Profitability Indexes Based on	
Profit before Tax	Net Interest Income
Net Profit	Net Fee and Commission Income
Earnings per Share	Total Revenue

The correlation of customer satisfaction from business performance Indices was carried out using the statistical methods of the Spearman's rank correlation coefficient ρ and Linear Regression. The Multi-criteria Satisfaction Analysis (MUSA) method was used in order to measure customer satisfaction. The method is an ordinal-regression based approach used for the assessment of a set of collective satisfaction functions in such a way that the global satisfaction criterion becomes as consistent as possible with customers' judgments. In particular, the method infers an additive collective value function Y^* and a set of partial satisfaction (value) functions X_i^* , given customers' global satisfaction Y and partial satisfaction X_i according to the i -th criterion (ordinal scaling). The main objective of the method is to achieve the maximum consistency between the value function Y^* and the customers' judgments Y . Based on the modeling of preference disaggregation approach, the ordinal regression equation has the following form:

$$\begin{cases} Y^* = \sum_{i=1}^n b_i X_i^* \\ \sum_{i=1}^n b_i = 1 \end{cases} \quad (1)$$

Where \tilde{Y}^* represents the estimation of the global value function, n represents the number of criteria, b_i is a positive weight of the i -th criterion, σ^+ and σ^- are the overestimation and the underestimation errors, respectively, and the value functions Y^* and X_i are normalized in the interval $[0,100]$. The global and partial satisfaction Y^* and X_i^* are

monotonic functions normalized in the interval [0,100]. Thus, in order to reduce the size of the mathematical program, the monotonicity constraints for Y^* and X_i^* were removed and the following transformation equations were applied:

$$\begin{cases} z_m = y^{*m+1} - y^{*m} & \text{for } m = 1, 2, \dots, a - 1 \\ w_{ik} = b_i(x_i^{*k+1} - x_i^{*k}) & \text{for } k = 1, 2, \dots, a_i - 1 \text{ } \forall i = 1, 2, \dots, n \end{cases} \quad (2)$$

where y^{*m} is the value of the y_m satisfaction level, x_i^{*k} is the value of the x_{ik} satisfaction level, and a and a_i are the number of global and partial satisfaction levels. According to the aforementioned definitions and the assumptions, the basic estimation model can be written in a linear program formulation, as follows:

$$\left\{ \begin{array}{l} [\min] F = \sum_{j=1}^M \sigma_j^+ + \sigma_j^- \\ \text{under the constraints:} \\ \sum_{i=1}^n \sum_{k=1}^{t_{ji}-1} w_{ik} - \sum_{m=1}^{t_j-1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \forall j = 1, 2, \dots, M \\ \sum_{m=1}^{a-1} z_m = 100 \\ \sum_{i=1}^n \sum_{k=1}^{a_j-1} w_{ik} = 100 \\ z_m, w_{ik}, \sigma_j^+, \sigma_j^- \geq 0 \quad \forall m, i, k, j \end{array} \right. \quad (3)$$

where M is the number of customers, n is the number of criteria, and x_i^{*j} , y^{*j} are the j -th level on which variables X_i and Y are estimated.

RESULTS AND DISCUSSION

Based on the results shown in Table 2 there is a positive correlation between global satisfaction and profitability indexes, but it is not statistically significant. The highest statistical correlation appears between the global satisfaction and the Net Profit index ($p = 0.347$). Particular emphasis should be placed on the existence of a negative correlation between global satisfaction and the indexes of Net Interest Income and Net Fee and Commission Income, which in essence translate into a positive correlation, since the existence of a negative correlation is also interpreted. Specifically, based on the negative correlation, the increase of customer satisfaction leads to the decrease in the indicators Net Interest Income and Net Fee and Commission Income. However, the reduction of the above indicators has a positive impact on the customer satisfaction.

Table 2: Correlation Profitability Indexes and Global Satisfaction (Spearman's rho)

Profitability Indexes Based on	Customer Satisfaction	Profitability Indexes Based on	Customer Satisfaction
Profit before Tax	0,274	Net Interest Income	-0,215
Net Profit	0,347	Net Fee and Commission Income	-0,309
Earnings per Share	0,244	Total Revenue	-0,165

** . Correlation is Significant at 0,01 Level (2 Tailed) / * . Correlation is Significant at 0,01 Level (2 Tailed).

As it is shown in Table 3 it appears to be a positive correlation between the satisfaction of the product-services criterion and the profitability ratios. The statistically highest and positive correlation was reported at the earnings per share index ($p = 0.694$). Besides, a statistically significant correlation was shown in the net profit index ($p = 0.547$).

Table 3: Correlation Profitability Indices and Satisfaction Criteria (Spearman's rho)

Satisfaction Criteria \ Indices	Profit before Tax	Net Profit	Earnings per Share	Net Interest Income	Net Fee and Commission Income	Total Revenue
Products-Services	0,497	0,547*	0,694**	-0,491	-0,018	-0,391
Stores	0,135	0,197	0,079	-0,426	-0,235	-0,379
Human Resources	0,465	0,485	0,371	0,050	0,065	0,200
Customer Service	-0,091	-0,174	-0,218	0,209	-0,371	0,126

** . Correlation is Significant at 0,01 Level (2 Tailed) / * . Correlation is Significant at 0,01 Level (2 Tailed).

SUMMARY AND CONCLUDING REMARKS

In a highly competitive environment customer satisfaction is crucial in acquiring comparative advantage and contributing at the survival of companies. This finding is especially determining the banking sector, which is one of the most dynamically and rapidly growing sectors of the Greek economy. The results of the present study confirmed the perception of researchers regarding the proven positive relationship between customer satisfaction and profitability. These results further signified an important aspect for business analysis, arguing that while the majority of firms are recognising customer satisfaction as a tool for their strategy development, they do not utilize relevant indicators in measuring their performance. Therefore, it is of utmost importance factor for contemporary firms to utilize customer satisfaction as a valuable managerial indicator to obtain quantitative information for their performance. Based on this analysis future research orientations are proposed. First, intensified analytical researches that include the above-mentioned factors related to customer satisfaction, they should be conducted. Second, at the same time the questionnaire structure could be enriched by more criteria concerning the customer satisfaction at the banking sector. Third, an important methodological advancement should be the installation, and annually running, permanent satisfaction barometer.

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Digital Marketing in Tourism: Insights from Greece

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Abstract

Nowadays, digital marketing is an inseparable part of every successful business. The increasing role of digital channels such as websites and social media in consumer behaviors is changing the way businesses are promoted and how they interact with leads and clients. Marketing procedures especially, within the tourism industry, have undertaken significant changes since customers have constant access to online information and special travel offers. This paper examines digital marketing used by travel companies. It consists of three parts: (i) a literature review to identify the digital marketing techniques within the travel industry, (ii) a manually performed analysis regarding the digital presence of almost 3000 travel companies in Greece and more specifically in the Halkidiki region, a summer destination in Northern Greece and (iii) a survey conducted to recognize the perceived benefits and the use of digital marketing by these companies. Results indicate that travel companies in Greece underuse digital marketing since they do not implement a holistic digital marketing strategy and highlight that there is an increased need for digital marketing solutions in the travel sector.

KEYWORDS

Digital Marketing, Tourism industry, Social Media, Websites, Search Engine Optimization

INTRODUCTION

More than 4.5 billion people now use the Internet, a number which reflects nearly 60% of the world's population (Kemp, 2020). The Internet has greatly affected the tourism industry in many ways; it has become one of the most effective means to approach existing as well as new customers while becoming a top preferred source of information for tourists due to the various online communities that are able to access it and utilise it effectively (Pantano and Di Pietro, 2013; Liu and Park, 2015). It also greatly contributes to the organizations and businesses by enabling them to have a more direct connection with their buying audience and prospective customers. Furthermore, this technology has also raised the bar in terms of competitiveness, thus rendering businesses that chose not to align with current online practices and procedures, unviable, obsolete and ultimately resulting in loss of their market presence (Mamaghani, 2009).

Furthermore, digital marketing and its applications have been acknowledged as effective tools that can be utilised by businesses in order to increase their profits as well as to be advertised to existing and developing markets overseas (Batinić, 2015). Incorporating digital marketing techniques is imperative for the tourism industry (Ratiu and Purcarea, 2015). In line with this, research findings evidence that 55% of European Internet users booked their accommodation for their travel destination online (Eurostat, 2016) and highlights that the increased use of digital marketing by the Greek tourism industry contributed to an increase in employment rates within tourism-related job roles by 12% (Tourism Economics, 2017); this directly impacts on Greece's prospects for further financial development.

The present study initially conducts a literature review in order to identify the individual techniques of digital marketing and their significance for the tourism industry. It then goes on to present two sets of research findings based on research that was conducted during the periods of November 2017- February 2018 with 3000 businesses in the Halkidiki area of Northern Greece participating for the purpose of mapping out the use of digital marketing techniques by these businesses. Results are then presented based on questionnaires completed by business owners within the tourism industry regarding their use of and views on digital marketing.

DIGITAL MARKETING IN TOURISM

Digital marketing is an integral part of every business that mainly affects how it is being promoted to existing and potential customers. This growing need for digital marketing is crucial in the tourism industry, where customers have continuous access to new information, offers and adjusted prices. A business within the tourism industry applies a digital marketing strategy in order to create appealing digital content to gain recognition, to create specific advertisements to attract its target audience, to engage in ongoing communication with customers for them to maintain satisfaction and loyalty to the business brand, to maximize its bookings and

subsequently its profits. In order to achieve the above it needs to apply a complete digital marketing strategy which will comprise of the following features (Kaur, 2017): 1) Quality, functional and mobile-friendly website, 2) (Search engine optimization), 3) Strong social media presence), 4) Online Advertisement.

Functional and responsive website

A well-structured website is essential for the online presence of any business. It helps transcend any geographical boundaries as well as to provide access to it whenever people wish. The Website is the initial point of contact with the user; it is the image of the brand (Wolfenbarger and Gilly, 2003). Visitors evaluate a website from the first point of contact they make with it, thus making it very important that the site is built in a way that is attractive to people. When a website is developed for a service catering to tourism related needs, there are different features of usability that need to be taken into consideration like navigation and design. Travel websites are recommended to have a good navigational flow with call-to-action buttons in order to improve conversion optimization (Hernandez and Resnick, 2013), be organized and have interactive content (Muhtaseb, Lakiotaki and Matsatsinis, 2020). Furthermore, some useful features in terms of a business website for tourism are setting an online booking system (Sun, Cárdenas and Harrill, 2016), having an up to date blog section with useful articles and information regarding the travel destination (Jeong *et al.*, 2012; Luna-Nevarez and Hyman, 2012), having professional photographs depicting the destination and product (Schmallegger, Carson and Jacobsen, 2010), making the website accessible in different languages (Lian *et al.*, 2017) and the option to action email marketing processes through data collection for prospective customers in Customer Relationship Management databases and newsletters. Email marketing as a technique is part of maintaining functionality for a website as its users interact with it and trigger actions of the CRM system. It is worth mentioning that email marketing must be programmed and executed properly to obtain maximum results. The messages that are sent ought to be personalized and indicate that the business cares for its customers. There is some evidence (Gupta, 2019) that email marketing is the best channel in terms of return on investment. It is mentioned that the best moment for this tool is when someone is in the process of making decisions about a trip to promote appealing offers to them.

SEO and tourism business

Optimization for search engines is a complex process which requires knowledge around the way that these operate in order to understand it; search engines class websites regarding search results based on criteria for specific words or key phrases that are inserted by the user in the search bar, such as Page Size, Website Loading Time, SSL Certificate, Keyword Density in Text, Keyword in H1/H2/H3 Tags, Quality and Quantity of Backlinks, Text to Code Ratio, Unique - High Quality Content, Image Alt Text, Internal Linking, Responsive layout (Ziakis *et al.*, 2019). Tourism websites administrators should take classification criteria into consideration and apply them to their e-pages in order to generate valuable traffic (Konidaris and Koustoumpardi, 2018). Travelers not only search for information regarding their travel destination whilst being in their country and planning for their holiday, but also do so through search engines while being on holiday regarding daily activities and therefore, the SEO technique gains even higher value (Manfron, 2018).

Social Media Presence

Social Media can be directly linked to tourism as it is based on information; and information is what tourists are looking for in order to book a trip (Gretzel, Yuan and Fesenmaier, 2000; Wang, Yu and Fesenmaier, 2002). The travel experience itself cannot be assessed before the actual trip as it is an intangible service, therefore the opinions of other travelers are highly important and influential (Gretzel, Yuan and Fesenmaier, 2000; Buhalis, 2003; Litvin, Goldsmith and Pan, 2008). This public sharing of information that is happening through social media has a great effect on the tourism industry, while travelers are using social media and other sites like Tripadvisor as sources of inspiration, information and programming for their trips (Latif *et al.*, 2020). Nowadays the decisions of the customers depend exclusively on the identity of the brands and other people's reviews of the company (Gupta, 2019).

Online advertising and third-party websites

There are different types of online advertising (Zeff and Aronson, 1999). One of the most well known and effective ways to advertise businesses within the tourism industry is through utilizing Google Ads as an advertising tool which allows advertisements to appear first among the sponsored search results generated through search engines as well as in many third party websites as part of the Google Display Network (Pan *et al.*, 2011). In line with this, maintaining a complete online presence in highly recognized OTAs (online travel agencies) such as Booking.com in combination with positive service user reviews is a significant online promotion technique.

METHODOLOGY

This research study aims to identify whether Greek tourism businesses implement the aforementioned valuable digital marketing tools to their benefit.

In order to conduct the present research, the methodology followed these steps: During the sampling stage, an exhaustive mapping of existing businesses was conducted through using search engines (Google.gr), lists of businesses (halkidikitavel.com, xo.gr, booking.com, Tripadvisor.gr, vrisko.gr) as well as websites for tourism businesses associations (kassandrahoteles.gr, grhotels.gr, greekhotels.gr) in order to identify these. Through the sampling process 3016 tourism businesses were identified and each one of

these was individually and manually checked regarding their online presence in order to identify their use of digital marketing techniques based on the literature review that was conducted prior to this.

The businesses that were identified and studied during the mapping stage are classed in these categories:

Table 1 Number of businesses grouped together by category in Halkidiki

Room rentals	Hotels	Campings	Gastronomy	Café/ Bars	Travel agencies	Real Estate	Car/ Motor Rental	Total
1668	276	40	394	419	69	57	93	3016

During the second stage of the research, a questionnaire was designed in order to administer it to businesses included in the sample to focus on researching the extend of the implementation of Digital Marketing techniques: Website, SEO, Social Media Marketing, Online Advertising & Third-party websites, E-mail marketing.

Through the initial mapping stage, 1646 businesses were identified utilizing a public email address to which the research tool was sent. In 425 cases of these businesses the invitation email sent bounced back, while it was received by 1221 businesses. The responses were electronically collected through the Google Forms platform and based on the final number of completed questionnaires, the response rate in the research came up to 20%; this is deemed as satisfactory as the questionnaire was completed by 245 out of 1221 businesses with an active email account.

Findings

The profile of the studied businesses is tourism businesses that operate in Halkidiki. Amongst these, 75% employ up to 5 employees, while barely 6% of the businesses employ more than 30 employees. With regards to their annual advertising budget for digital marketing, 51% of the businesses spend up to 1,000 €, 18% spend between 1,000-5,000 €, 10% spend up to 10,000 €, while barely 4.2 % of the businesses spend over 10,000 €. It is worth noting the fact that digital marketing budgets are 50% compared to offline marketing. In summary, the use of digital marketing techniques by the two most prominent tourism business categories in Halkidiki are presented in the table below, as identified through the aforementioned mapping process conducted in the present research.

Table 2 Use of digital marketing techniques in travel industry in Greece

		Hotels	Room rentals	Food & Beverage
	Number of companies	276	1668	813
Website related characteristics	Existence of website	90%	58%	9%
	Responsive website	64%	38%	5%
	Online booking system	61%	31%	3%
	Call to action button	37%	21%	5%
	Multilingual website	46%	26%	3%
	Up-to-date blog section	8%	7%	0,5%
	Professional Photography	75%	45%	6%
	Mobile Application	4%	0%	0%
Social Media presence	Managed Google By Business account	86%	61%	8%
	Public e-mail address	88%	62%	21%
	Facebook	71%	42%	18%
	YouTube	11%	3%	0,5%
Online advertising	Google AdWords	32%	20%	2%
	OTAs and third-party websites (booking.com or tripadvisor.com)	94%	70%	75%

As it is evidenced in the present research findings, hotels adopt digital marketing technologies much more easily compared to room rentals. That said, the level of digital marketing utilized within the hotel industry is far from ideal. Website rates appear to be particularly satisfactory since the majority of accommodation settings have this feature. Websites, however, are also evaluated based on their functionality and results here appear to be disappointing, as 68.2% are not mobile friendly, 74.1% do not provide the option for online bookings, 61.7% do not have professional photographs available online and 83.3% of the websites do not have an easily accessible call to action button. Search engine optimization is the process with which websites appear higher in search results (search engine result pages) for specific keywords (search queries / keywords). Results analysis highlights that 47% of the businesses are not aware of this technique, while 17% considers SEO services to be costly. With regards to the business's social media presence and whether they use Facebook and YouTube to promote their business content, manual mapping of the sample highlighted that 55.1% has a company page on Facebook whereas only 4.9% has a YouTube channel. The online promotion section includes Google AdWords and collaboration with third-party platforms like Booking.com. Overall, it was observed that 15.4% of businesses maintain AdWords

campaigns while 79% collaborates with third party platforms for online promotion and especially with Booking.com with regards to accommodation, even if they do not have a website.

CONCLUSIONS

It appears that businesses within the Greek tourism industry adopt digital marketing techniques that can be implemented easily, fast and without high cost, such as their online presence on Google My Business as well as their presence on social media. However, utilizing social media marketing effectively requires further research. Finally, important digital marketing techniques that can be highly effective, such as search engine optimization, targeted advertising on Google AdWords and utilizing mobile marketing through specialized applications for mobile devices, are not widely used. These results indicate that there is a need for further knowledge of such techniques and a higher budget for marketing departments, given that the average annual budget is only 101-1.000 euros. Moreover, the percentage of their annual advertising budget spent on digital marketing compared to traditional marketing is just 54%, a rather low percentage, given the importance of the digital implementation compared to traditional offline approaches. Finally, when asked how they implement these marketing techniques, the most common answer given was that they implement them themselves, while the lack of specialized staff for these techniques was quite obvious, which can lead to their subsequent misuse. In conclusion, the present research highlights that the tourism industry in Northern Greece is not effectively using of all the digital marketing techniques and tools that are currently available. There is still room for improvement and further knowledge to be explored in order to consider more techniques through future possible avenues of research around digital marketing while also perfecting existing ones. The gap in this field is an opportunity for professionals within the tourism industry to explore competitive advantages that will result from implementing complete digital strategies and will therefore contribute to local and national financial development.

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Mapping Business Model Using Archimate: The case of Open Data Ecosystem

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Abstract

Open data increases the value between all actors in an open data network. While value network organizations may benefit greatly from the business opportunities provided by open data, the lack of value network and business models has been noticed as the major challenge to data use in services and applications. Open data gives businesses numerous opportunities, such as developing new products and services. Collaboration between data-providing actors, for data-consuming actors and for actors designing new data services and applications is a major challenge for companies and governments. Those actors synthesize an ecosystem called the collaborative environment. There are many obstacles facing open data ecosystems and researchers have focused on establishing and validating those. From a business perspective the existing knowledge about the open data ecosystem is limited. The aim of this paper is to visualize the business model of open data ecosystem in Thessaloniki with a view to discuss the relationships between the actors of the open data network as well as the business model elements required to sustain the activities of these entities in open data based business. Findings indicate that while participants are interested in using open data, there is a need for a new type of business model which supports a win-win situation possible for all participants in the open data setting. The findings showed that an open data ecosystem has multiple incentives and benefits. However, there are still obstacles that need to be carefully approached.

KEYWORDS

Open Data; Business Model; Ecosystem; Modeling; Archimate.

INTRODUCTION

Within the fields of business and management the concept of a business model has become popular. The increase in the number of publications relating to the subject is an indication of the increasing interest in this management area (Klang et al., 2014). It is important to note that the Business model concept and its related work are still considered fresh and modern, although they have appeared for nearly 20 years in academic journals (Pozi et al., 2016). Scholars realize the importance of the definition for the effective commercialization of a technology (Baden-Fuller and Haefliger, 2013; Chesbrough and Rosenbloom 2002), suggest the business model for the organization as a new unit of study for future value creation research (Amit and Zott 2001), and promote its ability to explain variables such as competitive advantage, firm performance and growth (Johnson et al. 2008; Zott and Amit 2008). Morris et al. (2005) stylizes the business model from an entrepreneurial point of view as the missing link in the literature, given market opportunities, creative business ideas, adequate resources and talented entrepreneurs, projects fail. Furthermore, management scholars emphasize in particular the importance of the business model concept for practitioners (Amit and Zott 2012; Kamariotou and Kitsios, 2017; Kitsios and Kamariotou, 2020; 2019c; 2019f; 2018a; c; 2017). In particular, academics promote its use as a representation mechanism to clarify the current or potential value development and value-capture process of an organization (e.g. Shafer et al. 2005), as a formal guide for how to communicate with business partners (Amit and Zott 2001), as a cognitive framework for converting technical input into economic production (Chesbrough and Rosenbloom 2002), and as a cognitive framework for converting economic output (Doganova and Eyquem-Renault 2009).

Most expensive IT innovation projects fail because the solutions and techniques they propose never materialize. Research years are being put into producing yet another working pilot demonstrating an innovative concept that will eventually fail to be implemented in real-life environments. The problem is often exacerbated by the push of technology, without careful examination of the issue within its context (Kitsios and Kamariotou, 2019b; 2017b; Meertens et al., 2012).

The design process should begin with the development and review of one (or more alternative) business model(s). This will then be converted and further developed into an enterprise architecture to ensure that the future framework is fit for market. To make this possible, the mapping of business model specifications requires a technique to design specifications in an automated way, where possible. A few other factors inspire this mapping besides being able to move

from business models to system design in a model oriented fashion. Such an optimization provides a framework for modeling business models in Archimate, facilitates the traceability of business requirements in the design specifications, enables the description and study of alternative business cases derived from a particular system's business model, thus facilitating (top-down) quantitative analysis of alternative architecture designs in Archimate. In other words, it allows for the company to measure (in a bottom up fashion) the shift benefit of an architectural transition.

Therefore, the purpose and contribution of this paper is to demonstrate the visualization of a Business model Canvas to enterprise architecture, using a case study of open data ecosystem in Thessaloniki. This analysis facilitates dialogue between the relationships between the open data network actors as well as the business model elements required to sustain these entities' activities in open data related business. The mapping was carried out using the Archimate, the enterprise architecture modeling standard of the Open Group, which is a modeling language and an open standard that were designed to specify architecture descriptions and their motivation, which are based on business goals to technology infrastructure.

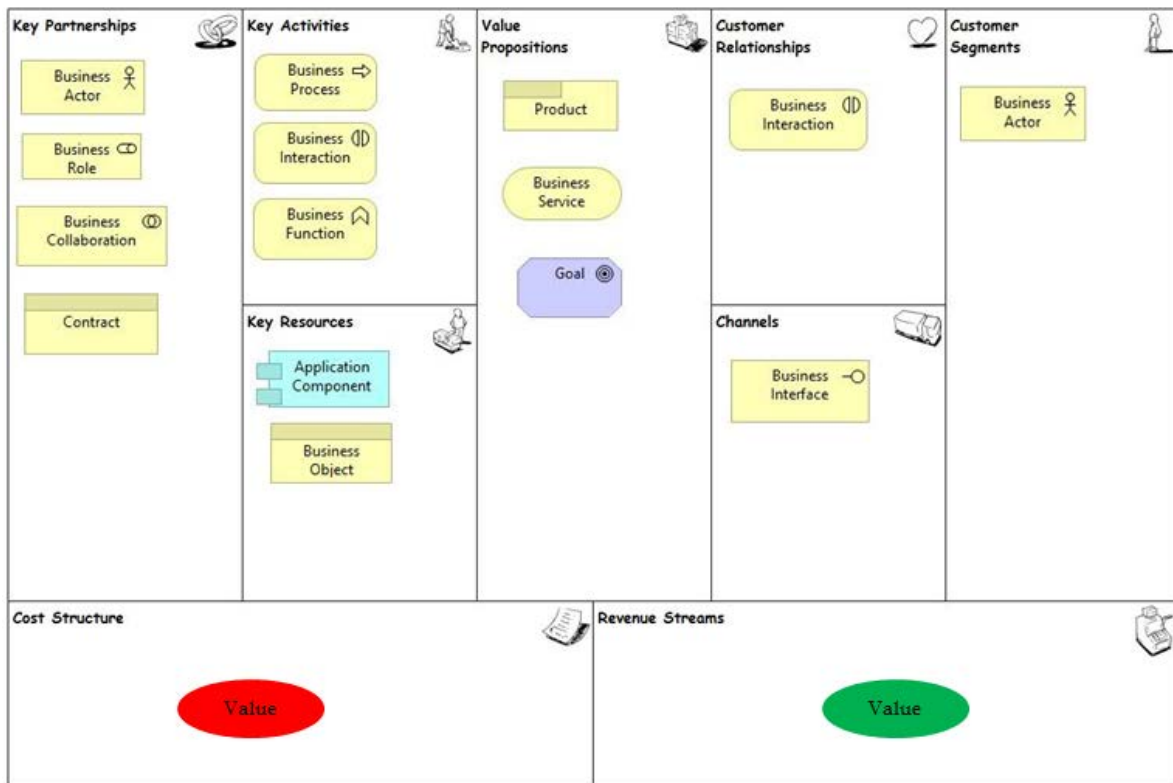
The layout of this paper is as follows: The next section, after a brief introduction to this area, is the theoretical background in respect of mapping of Business model Canvas using Archimate. Section 3 presents the proposed mapping. Finally, conclusions are presented in Section 4 and the paper ends.

MAPPING BUSINESS MODELS TO ARCHIMATE

A business model explains how value is generated in a company by management decisions and the effects that result (Kitsios and Kamariotou, 2019e; 2018b; Barrett et al., 2015; Lindman et al., 2015). Authors have chosen to use the business elements of the Business model Canvas because it is a well-known model and offers a structured framework for the development of new business models (Kitsios and Kamariotou, 2019d; Kitsios et al., 2017). This explains how an organization delivers value to one or more consumer groups, the market model and its partner network to build and distribute that value in order to achieve revenue streams and maximize profitability. Key elements involved in the model include key activities, key partnership, key resources, relationships with the customers, value proposition, customers, channels, revenue stream and cost structures. The customer segments building block includes the groups of individuals or organizations who are company clients that they wish to meet that represent. The building block of value proposition involves goods and services that generate value for a particular segment of the consumer. The building block of channels involves the ways a business communicates with and serves its consumers in order to deliver a value proposition. The building block of customer relationships represents the different types of relationships that a business develops with specific groups of customers. The revenue streams building block defines the revenues which a business earns from each customer group. The key resources building block contains required resources to make a business model work. The key activities building block represents the most important things an organization is expected to do in order to make its business model work. The building block of key partnerships describes the network of suppliers and partners with whom the business collaborates to make the business model work. The cost structure includes all costs incurred (Barrett et al., 2015; Lindman et al., 2015).

The (definitions of) concepts specified by Archimate were compared to the concepts defined by the Business model Canvas in order to define a mapping (Figure 1). In Archimate, key partnership building block defines the network nodes, i.e., the participants invoked in partnerships (actors, roles, and stakeholders) as well as their relationships and interactions. Such relationships or interactions can be defined in ArchiMate through contracts, business collaborations and business interactions, similar to the building block for the customer relationships. With regard to key activities, in the architecture domain, capability is defined as the ability of an entity (department, organization, person, system) to perform activities that will lead to the accomplishment of its goals, in particular in relation to its overall mission of making the business model work. Key resources reproduce the resource definition in almost literal terms. A very simple lexical analysis of the above definition already provides a clear indication of the Archimate concepts suited to modeling the value proposition. In addition to goods, business services and value, the goal concept is often included as most of the goals are designed with a view to raising some kind of value, and therefore provide a more detailed view of the value proposition by demonstrating why the product or service is useful. Customer segments in Archimate are modeled as actors, stakeholders or roles. The building block for the channels contains a specification of all business interfaces. The only concept of Archimate which can be used to model revenue and costs is value (Iacob et al., 2014; Meertens et al., 2012).

Figure 1 Relating Archimate and Business model Canvas

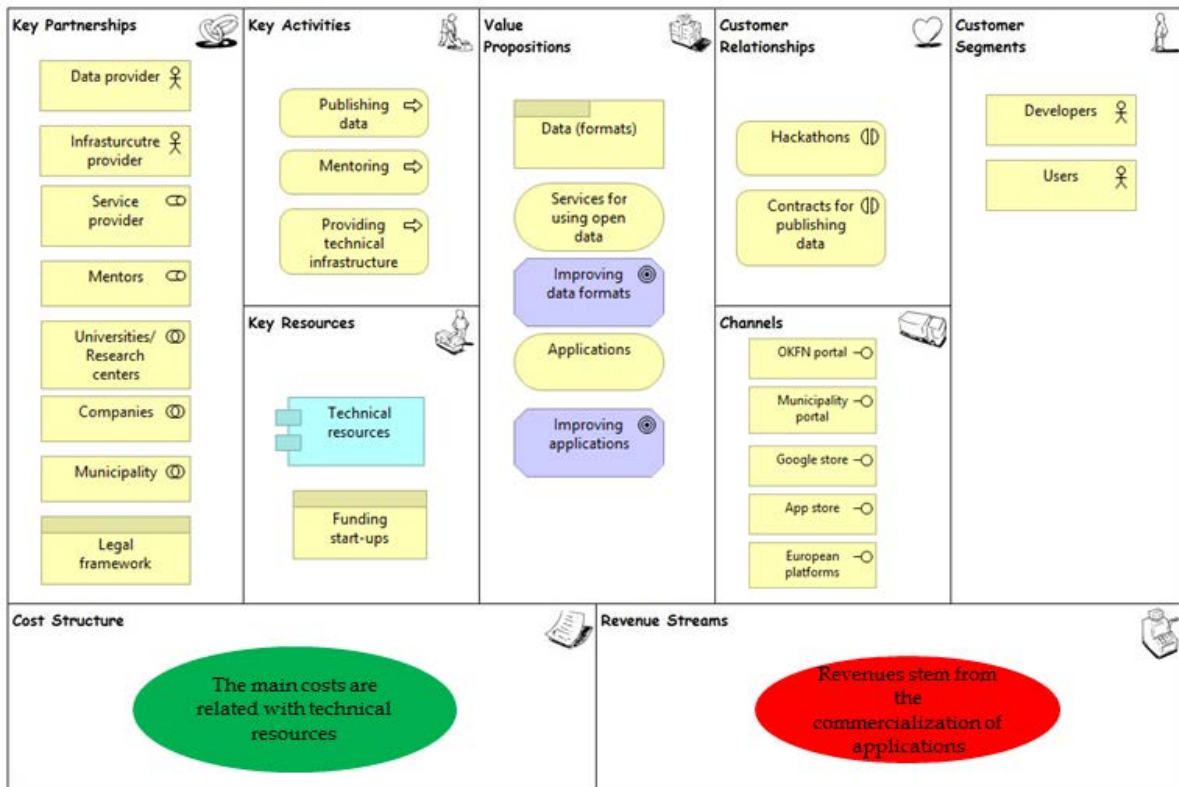


CASE STUDY

The Thessaloniki's open data ecosystem consists of data providers, infrastructure and tool providers, service providers and developers of applications (Kitsios and Kamariotou, 2019a). Although in the city of Thessaloniki many competitions are organized the value is not promoted in the network. Incubators and mentors in entrepreneurship may participate in these hackathons and support developers of applications to further grow and launch their applications. Mentors and businesses should engage in the network to support application developers to broaden their applications and increase revenues. Public administrations seek to help developers broaden their applications in startups by engaging in competitions using open data. New startups and infrastructure providers may provide developers with tools and mentorship to commercialize their applications.

The value is created in the network because the actors participate and are working together. Actors could develop contracts that could enhance cooperation and distribute data among them without restrictions, and improve data quality. Free data quality is poor, as the format is not appropriate for storing data. The permanence of free sources of data is also believed to be unknown. Data is available through the portal of the Open Knowledge Foundation (OKFN) or the municipality portal. Applications are available to end users through App store, Google store or other European platforms. The Hellenic and European legal framework are required for data distribution, and these instructions must be followed. The major costs relate to technical resources. The main earnings for developers stem from the launch of their applications to the market. Figure 2 presents the mapping of Business model Canvas using Archimate for the open data value network in Thessaloniki.

Figure 2 Business model Canvas using Archimate



CONCLUSIONS

The main purpose and contribution of this paper is to map between the Canvas Business Model and Archimate. The concept of such an optimization between the de facto standards in business modeling (Business model Canvas) and enterprise architecture (The Open Group's enterprise architecture modeling standard, Archimate) provides a framework for modeling business models in Archimate. It makes it easier to track requirements from business demands down to the specifications for design. It helps to examine the impact of shifts in business models on architectural design. Further research can therefore suggest that alternative architectural design approaches can be followed quantitatively in terms of costs and benefits. The optimization can also be used the other way around to evaluate the effect of a shift in architectural design on the underlying sector.

The Business model Canvas and Archimate have been compared for the mapping. There were mappings of both definitions and relationships. The optimization is complete in the sense that every concept can be mapped into at least one Archimate concept from the business model canvas. The optimization is less than optimal, as many concepts are overloaded or redundant, and many Archimate's concepts are excessive for the Business model Canvas (and perhaps business modeling in general). Missing consistency in mapping makes the mapping harder to reverse.

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Determinants of User Satisfaction with a Justice Information System

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Abstract

Information and Communication Technologies (ICTs) have been increasing in the public sector during the last decade. The adoption of ICTs in e-government and particularly in courts offers many benefits and more effective services for citizens and users. Information Systems in justice increase engagement and communication between different actors and support lawyers and judges in streamlining their day to day work. In addition, Information Systems in the justice sector have encouraged the development of new working practices and organizational procedures to improve the performance of the court. Several court management scholars and practitioners have paid attention to this field, and the money spent on improving the performance and output of court staff has increased, studies that examine the acceptance and user satisfaction of Information Systems in the justice sector are limited. Consequently, the purpose of this paper is to examine the factors affecting user acceptance and satisfaction of Information Systems in the justice. Data was collected by 125 lawyers in Greece. Regression Analysis on the detailed items of user acceptance and satisfaction constructs was applied. The findings of this paper denote the attention given by lawyers to the dimensions of system quality, information quality, perceived usefulness and perceived user friendliness. In addition, this paper is useful to judicial authorities and practitioners to design these systems more efficiently and to consider these variables closely in the design and use of court systems.

KEYWORDS

E-justice system; Information Systems; Satisfaction; Success; Information Systems acceptance.

INTRODUCTION

E-justice systems that are part of e-government have been established as in other parts of the public sector to ensure a quick, effective, efficient, and accurate judicial system. The main aims of these systems is to increase the quality and performance of the infrastructure and the interaction between various actors (Agrifoglio et al., 2016; Oktal et al., 2016; Sachan et al., 2018; Stefanovic et al., 2016; Wang and Liao, 2008). IT solutions have been built with the context of e-justice to enable layers and staff to conduct their daily action at work. Such court-management technologies boost administrative staff's job performance as they have been promoting the implementation of innovative work practices. In e-justice systems the information is available to all users in the central electronic environment. Registered users are layers, judges, solicitors, and other judicial staff. E-justice systems make access to this information fast and convenient. In addition, e-justice systems require users to perform all forms of information and records in online environment. The main aim of an e-justice system is to establish a faster, more reliable information, documentation, and workflow of incompliant judicial services (Agrifoglio et al., 2016; Oktal et al., 2016).

The e-justice systems are used by user groups in organizations. In this study this is why factors affecting internal user's assessment of IS success and satisfaction are examined. Previous researchers have used current IT/IS related models to help businesses to adopt effective IS. Some of these models are the Technology Acceptance Model (TAM) which was suggested by Davis, (1989), the Theory of Planned Behavior (TPB) which was studied by Ajzen, (1991), and the unified theory of acceptance and use of technology which was used by Venkatesh et al., (2003). Factors can influence IS and user behavior are crucial because they affect the IS development successfully. Thus, assessment models were introduced to consider user needs and to analyze the factors affecting user acceptance and satisfaction during IS growth (Kamariotou and Kitsios, 2019; 2017; 2016; Kitsios and Kamariotou, 2017).

Existing studies in the field of e-government have looked at public satisfaction as the end users. There are minimal research about the acceptance and satisfaction of internal users. Furthermore, current IS assessment models focus on system-centric evaluation or organizational structure. Researchers have not yet addressed user-centric evaluations of e-justice systems. To develop a successful e-justice system, it is important to achieve a level of performance that primarily satisfies the majority of internal users (Agrifoglio et al., 2016; Oktal et al., 2016; Stefanovic et al., 2016). Consequently, the aim of this paper is to explore the factors affecting the acceptance and satisfaction of Information

Systems in justice by users. Data was collected by 125 lawyers in Greece. Regression Analysis on detailed items of user acceptance and satisfaction constructs has been applied.

The layout of this paper is as follows sections: The next section, after a brief introduction to this area, is the theoretical background in respect of the satisfaction in e-government and justice. Section 3 explains the methodology, while Section 4 shows survey findings. Finally, conclusions are presented in Section 5 and the paper ends.

THEORETICAL BACKGROUND

Current literature suggests that the benefits of e-government systems do not reaching users as a result of which many e-government applications are termed as a failure or partially a success. Factors that influence e-government systems adoption behavior should be examined more closely as it remains a common subject of research on IS (Angelopoulos et al., 2010a; b; 2009; Kitsios and Skiadas, 2001; Kitsios et al., 2009; 2008; Sachan et al., 2018). In the justice sector in particular, researchers have measured user satisfaction which adapt three dimensions: quality of the information, quality of the service and quality of the system. The first dimension tests the content of IS including determinants such as precision, currency, timeliness of performance, reliability, completeness, conciseness, convenience and sufficiency. Level of service quality allows administrative workers to carry out their daily jobs. Thus, determinants such as information production, the user-friendly interface, system compatibility and technical staff skills are essential to help users. The third aspect pertains to IS production efficiency. Quality of service involves determinants such as information completeness, accuracy, format, currency, importance, timeliness, precision, reliability, usability, and conciseness to calculate the user satisfaction impact on this aspect.

Internal justice system users indicated that the quality of system and service has a direct but not high and positive effect on user satisfaction. Their expectations are focused on the quality of information, perceived ease of use and the interface of the system because they aim to do their work better. Users need timely information by accessing data in real-time; accurate information, fewer incorrect data entries and more consistent data entry across users over time. If the procedure related to legal assistance is complicated, the speed of the system is poor and technical staff cannot provide the help needed, therefore users are not equipped to use the e-justice system. Court administrative staff suggested that the greater the effect it would have on job efficiency, the more system is used and the court employees are pleased with it. Findings from surveys thus indicate courts that the availability of information influences user satisfaction rather than the efficiency and usage of the system (Agrifoglio et al., 2016; Oktal et al., 2016).

Based on the analysis of the existing literature, the following hypotheses are defined:

Table 1. Hypotheses

Hypotheses	References
H1: System quality positively affects user's satisfaction.	Agrifoglio et al., 2016
H2: Information quality positively affects user's satisfaction.	Agrifoglio et al., 2016
H3: Service quality positively affects user's satisfaction.	Oktal et al., 2016
H4: Perceived ease of use positively affects user's satisfaction.	Hudson et al., 2018; Oktal et al., 2016
H5: Perceived usefulness positively affects user's satisfaction.	Rai et al., 2002

METHODOLOGY

To assess the satisfaction of lawyers and the acceptance of the e-justice system in Greek courts, a questionnaire was drafted. 125 lawyers who use e-justice system in court in Thessaloniki completed the questionnaire. Variables used in order to assess user satisfaction relate to system quality, information quality, service quality, perceived usefulness and perceived ease of use. System quality tests the satisfaction a user receives by using the e-justice system. The quality of information refers to measurements used to assess the quality of information received by the e-justice system (e.g. accessibility, reliability, usefulness, output). Quality of service demonstrates satisfaction of the service rendered by the e-justice system. This criterion measures the availability of the system, the readiness and specific needs of users, the skills and experience of technical staff to support users, as well as the security of transactions that are carried out through the system. Perceived ease of use refers to the ease of use, ease of learning, flexibility of the e-justice system, user abilities and user engagement with the system. In the end, perceived usefulness includes dimensions such as enhancing job efficiency and improving the consistency of the e-justice system employed by the user (Agrifoglio et al.,

2016; Delone and McLean, 2003; Kitsios et al., 2019; Oktal et al., 2016; Rai et al., 2002; Sachan et al., 2018; Stefanovic et al., 2016; 2011; Wang and Liao, 2008). The five-point Likert scale was used to operationalize the described constructs mentioned above. Analysis of the data was carried out using Regression Analysis.

RESULTS

In terms of descriptive statistics, 56% of responders were men while 44% of them were female. The majority of the sample is between 36-45 years old (37%) while 26% are those who belong to the ages between 46-55 years and 20% are those who belong to the ages 26-35 years old. 28% of respondents work for more than 20 years while 22% work from 10 to 15 years and 20% from 15 to 20 years. 48% of the sample are layers Despite the Court of First Instance, 30% are lawyers of the Court of Appeal and 22% are lawyers of the Supreme Court. Finally, 70% of respondents have their own law firm, 25% work with other lawyers and the remaining 5% are members of a law firm.

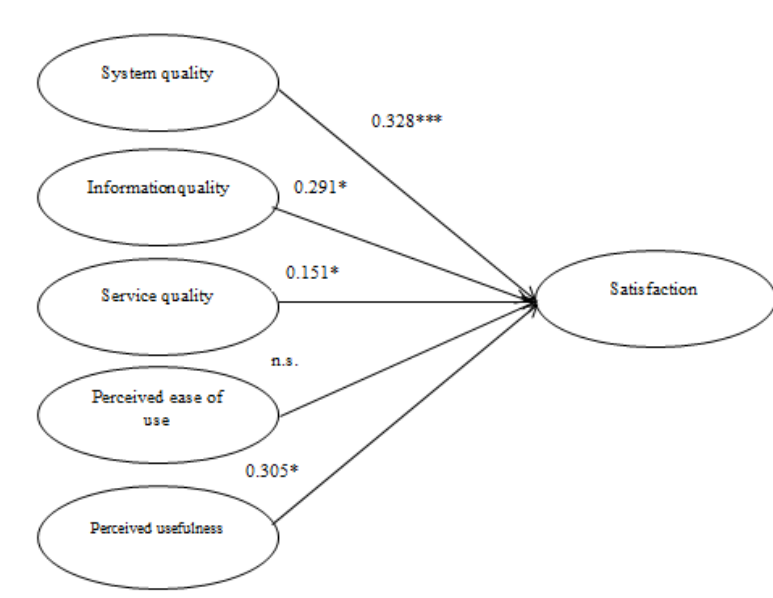
The path coefficient between System quality and Satisfaction was positive and statistically significant ($\beta= 0.328$, $p<0.001$). Thus, H1 was supported. Furthermore, there was a positive and statistically significant relationship between Information quality and Satisfaction ($\beta= 0.291$, $p<0.05$) and Service quality and Satisfaction ($\beta= 0.151$, $p<0.05$). Thus, H2 and H3 were supported. The path coefficient between Perceived ease of use and Satisfaction was positive but not statistically significant ($\beta= 0.120$, $p>0.05$). Thus, H4 was not supported. There was a positive and statistically significant relationship between Perceived usefulness and Satisfaction ($\beta= 0.305$, $p<0.05$); thus, H5 was supported. Table 2 and Figure 1 present the results of Regression analysis.

Table 2 Regression Results

Independent variables	β	t	R ² (Adj.)	F
Model			.658	48.761
System quality	.328	3.910		
Information quality	.291	3.116		
Service quality	.151	2.085		
Perceived ease of use	.120	1.289		
Perceived usefulness	.305	3.557		

*Significance at <0.05, **Significance at <0.01, ***Significance at <0.001

Figure 1 Conceptual model



Four of the five cases under consideration are confirmed. The quality of the system, the quality of the information, the quality of the service and the perceived usefulness of the system are the variables that positively affect the overall satisfaction of layers, while the perceived ease of use of the system does not seem to affect it much. In this group, the quality of the system affects the overall satisfaction more than the other variables. It seems that layers are more

interested in an overall good picture of the system, ensuring the quality dimensions of the application, which will make it useful for its daily work activities.

Comparing the results of the present work with those of the authors of the articles in the literature review, it is worth noting that their findings are mainly coincidental. Indeed, according to previous research, all three dimensions of quality have immediate and positive effects on the satisfaction of internal users of respective programs, with each of these dimensions playing a more important role in overall satisfaction, depending on the research under consideration (Agrifoglio et al., 2016; Oktal et al., 2016; Stefanovic et al., 2011). At the same time, the ease of use and perceived usefulness, the two key factors in accepting information systems have a positive sign in most surveys, which is related to the degree to which users believe the program will help them perform their work better (Oktal et al., 2016; Rai et al., 2002; Sachan et al., 2018).

CONCLUSIONS

The aim of this paper was to analyze the factors influencing the acceptance and satisfaction of Information Systems in justice by users and in particular by Greek lawyers. This study presented an assessment model of an e-justice system from an internal user perspective. This analysis utilized variables that previous studies used to assess user satisfaction and IS acceptance. Aspects of IS performance may be evaluated and used based on various models. Moreover, behavioral IS usage models could be used in order to explain IS usage in different settings (such as operational, tactical and strategic level) where IS usage can be assessed through time spent on the system. Future researchers could use other methods for data analysis (e.g. SEM) in order to provide a better understanding of the relationships between variables. The results of this study reflect the attention provided to enhancing the efficiency and performance of e-justice systems by court users, authorities and suppliers of applications to consider these factors in the design and use of court systems. Besides, this study is useful to judicial authorities and professionals in order to design those systems more effectively and to closely consider these variables in the design and use of court systems. Due to the growing use of IT for the delivery of public services, a greater understanding of such constructs necessary for increased acceptance. For agencies which provide e-justice services, it may also be crucial.

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Estimation of choice model for parcel delivery services

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Abstract

The rapid growth in e-shopping has driven to a large extent business to consumer (B2C) parcel deliveries. Whereas the parcel delivery service is an Agreement between the Transport Service Operator with the E-retailer, the service level of Agreement is determined by consumer demand. The critical element to complete an electronic purchase is the physical delivery, therefore particular attention should be given to the service provided to the customer. The aim of this paper is to use a multinomial discrete choice model to analyze the service attributes that consumer considers more important. These attributes such as: delivery place, time and speed, track and trace, value-added services and delivery cost constitute four alternative delivery services. Stated Preference Experiments were developed to collect data on respondents' choices among hypothetical situations. Results have shown that consumers prefer Free Delivery Service but they are willing to afford a higher price if they have the option to choose a more advanced parcel delivery service providing a higher service level.

KEYWORDS: e-shopping, parcel delivery services, multinomial discrete choice model, Stated Preference Experiments

INTRODUCTION

Having completed an online order, then consumer chooses the delivery service that is most appropriate for him/her. However, this choice depends on the service attributes as well as on product type and value, therefore user needs are considered to determine the differentiated services to deliver an online order at the final destination.

The results of IPC (International Postal Corporation) of the most recent survey held in 2019, for e-shopping and delivery services have shown in terms of parcel delivery service attributes, that the most important factors for consumers were delivery location at 71%, delivery cost at 65% and speed of delivery at 39%. In addition, was "Clear information" about delivery charges and pre-purchase at 66%, whereas the least important elements were "possibility to re-route packages while in transit" at 20% and "possibility to select delivery company" at 22%.

In the academic literature review, they were found many studies on this field, such as the importance of time and convenience (T. Gawor et. al., 2018), e-shoppers' valuations of delivery service attributes such as delivery speed, time slot, daytime/evening delivery, delivery date and delivery fee (D.H. Nguyen, et. al., 2019), the effect of final delivery solutions such as automatic delivery stations (Z. Xiao et. al., 2018, L. de Oliveira et. al., 2017) and customers' choice behavior for express delivery services (L. Lian et. al., 2015).

Considering, the findings of IPC and of academic literature the delivery service attributes that can determine consumers' choice of parcel delivery service are time, place, and cost of delivery. They can also be added track and trace services and value-added services as they were referred to IPC annual survey. One main contribution of this paper is the application of advanced econometric methods to gain a thorough understanding of consumers' decision making for parcel delivery services which can be used from practitioners and academics for this topic of e-shopping and delivery services which is a highly evolving business sector.

THE PARCEL DELIVERY SERVICE FOR E-SHOPPING

When consumer completes an online order, then has to enter an address where to deliver his/her online order. Therefore, the place of delivery is the first main element of the delivery service, and it consists of two basic delivery options: 1) the transporter delivers the shipment to the customer, that is at home or at workplace or 2) the customer has to pick up the shipment at a specific location. Consumers prefer delivery at home, as it offers greater convenience, but some others may choose to collect their online order from a pick up point due to the fact that they are not at home during the normal working day. The second aspect is mostly related to timeliness and delivery speed. Transport service providers segment their price catalogue based on time velocity into same day, next day, or two and more days (Huebner and Kuhn, 2016), whereas e-retailers offer to their customers to choose between standard and express delivery. Delivery

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lead time refers to the duration of time from when an order is placed until the customer receives the purchased items whereas the time-slot refers to the specific time of the day that consumer will be at home to receive the online order. The third element of a parcel delivery service is to provide to consumer track and trace services, to be able to identify order status from the time the order is placed until the final point. Track and trace services are based on automatic identification of the parcels' location and status by the use of technologies such as RFID, barcodes, etc. Consumer is interested in receiving clear delivery information, to have the feeling of shipment control, like the ability to schedule a late delivery, or having a delivery window. The fourth service attribute is about the provision of value-added services, like shipment insurance, cash on delivery, free return service and the like which these may have an additional cost for the consumer to incur. This is why, these additional services increase the operators' time and effort in the final receipt process with the e-shopper. Finally, the delivery cost, concerns the fee that the consumer has to pay to receive his/her online order. The shipping fee that is set by the e-retailer on the purchase order can be a key marketing decision to consumers with specific delivery service preferences. The cost of shipping fee depends on how fast consumer needs to receive the order, the geographical area that is located or any other supplementary services that he/she may request. The description of the five service attributes as well as their levels which constitute them are listed below:

- **Delivery Place:** at home, pick-up point [Reference Level]
- **Time and Speed of delivery:** standard delivery (3-7 days) [Reference Level], express delivery (1-2 days), next day delivery, delivery at a specific time-window, Saturday morning delivery
- **Track and Trace:** full track and trace services [Reference Level], notification messages for order status (email/sms/app), notification messages for the expected day and time of delivery
- **Value – added services:** indemnity in case of unreliable delivery service (time, cost, etc.), cash on delivery, possibility to change shipment route in case of consumers' absence from home, free return [Reference Level]
- **Delivery Cost:** 0€ [Reference Level], 2€, 3€, 4€, 6€

METHODOLOGY

Based on literature review an electronic questionnaire was developed using Sawtooth Software. The research conducted during May 2018 up to October 2018 and it was disseminated electronically through social networks. The survey took place in Greece and respondents were mainly located in Athens and only a small percentage, approximately 20% of the population was located in Thessaloniki.

They have been collected 228 valid questionnaires which the amount of these respondents resulted to 1596 observations (228 x 7 scenarios). The data collected concern consumers' most recent electronic purchase, consumers' perceptions and attitudes for e-shopping and delivery service, socioeconomic characteristics, whereas Stated Preference Experiments were used to collect data for consumers' preferences on delivery service alternatives.

A choice set was designed to offer to consumers a series of menus of alternative options defined as (*Free Delivery, Economy Service, Standard Delivery Service or Special Delivery Service*). Also, a 'No-choice' option is provided to allow participants not to choose any of the services presented in any of the seven scenarios in the choice experiment. The values representing each alternative were allocated in such a way to describe a different service. The above description leads us to the use of a multinomial logit (MNL) model to determine the probabilities of choosing j options. The analysis of stated preference data was made using R and have given the relevant coefficients for each of the three service alternatives as they described in the next section.

MODEL APPLICATION FOR CHOICE OF PARCEL DELIVERY SERVICES

The attractiveness of an alternative is evaluated in terms of a vector of attribute values which the participant will trade-off and will choose the one that offers the maximum utility, thus consumer derives utility from the attribute levels. When using MNL model, choices must satisfy the Independence from Irrelevant Alternatives (IIA) property, which means that the addition or subtraction of any option from the choice set will not affect relative probability of individual n choosing any other option (Louviere, et al., 2000). The RUM model is based on the assumption that individuals know their utility with certainty, but analysts are unable to perfectly observe respondent utility so the unobservable elements are part of the random error. The random utility function for each alternative j is defined as:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \quad (4.1)$$

In this generalized utility function, V_{ij} is a vector of observed variables (observed utility) related to alternative j decision maker i , and ε_{ij} is an independently and identically distributed (IDD) extreme value error term representing unobserved influences on choice. One important property of discrete choice models is that only the differences in utility between

alternatives affect the choice probabilities—not the absolute levels of utility. It should be noted that labeled designs as in this research, permit the analyst to estimate a constant term specific to each alternative, known as an alternative specific constant (ASCs) which are typically included in the MNL model. The ASC for an alternative captures the average impact on utility of all factors that are not included in the model. Therefore, since only differences in utility matter, only differences in the alternative-specific constants are relevant, not their absolute values. The utility of an e-shopper n when considering which parcel delivery service to choose for the e-purchase j in the choice task t is described as follows:

$$U_{j,n,t} = ASC_{0j} + \beta'_1 DP_{j,n,t} + \beta'_2 T\&S_{j,n,t} + \beta'_3 T\&T_{j,n,t} + \beta'_4 VAS_{j,n,t} + \beta'_5 Cost_{j,n,t} + \varepsilon_{j,n,t} \quad 1 \leq j \leq 4 \quad (4.2)$$

Where DP denotes Delivery Place, $T\&S$ denotes Time and Speed, $T\&T$ denotes Track-and-Trace, VAS denotes Value-Added Services, $Cost$ denotes the cost of the alternative and β s in bold are unknown coefficients to be estimated. Specifically, β_1 is the coefficient representing the effect of the delivery place attribute (*Free Delivery, Economy Service, Standard Delivery Service or Special Delivery Service*) in choosing the delivery service.

The first four independent variables were categorical, therefore they were recoded and implemented in the model as dummy variables, thus for each attribute, we set a “reference level” (see, the above list on pg.2), which represents the maximum level of delivery service provided to consumers while they shop online, thus implying minimum levels of: delivery place, delivery time, track and trace, value-added services and cost. Under the assumption that the error terms (ε_{ij}) are iid (independent and identically distributed) and follow an extreme value distribution (Gumbel) then the probability that the decision maker with index i will choose alternative j is:

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_k e^{V_{ik}}} \quad (4.3)$$

The Free-Delivery Service did not allow the decision makers to adjust the attributes’ levels, therefore this service alternative was considered to be the reference alternative, thus its constant was normalized to zero. The selection of the referent alternative has no effect on the model, thus the utility of FD was zero:

$$V_{1j} = 0 \quad (4.4)$$

For the other alternatives, the estimated coefficients, along with S.E., are given in Table 1 in the next section. *Note that only significant predictors are included in the utility model ($p < 0.05$).* The fact that only differences in utility matter means that the only parameters that can be estimated are those that capture differences across alternatives.

MODEL ESTIMATION RESULTS AND INTERPRETATION

The coefficients that are estimated (Table 1) indicate the impact of each observed variable relative to the variance of the unobserved factors. The coefficients of the three alternatives-specific constants for parcel delivery services have negative sign that were significantly different from zero at the 0.01 level. The negative sign reflects the fact that e-shoppers when they will have to choose a parcel delivery service will tend, all else equal, to prefer ‘Free Delivery Service’ whereas the other three offered services were not attractive to the consumer. However, the fourth delivery service had the greatest negative coefficient comparing with the other two services because this service includes the greatest number of attributes levels comparing with the others, in consequence it starts from a very low level. For the attribute ‘Delivery Place’ the coefficient of the dummy variable for ‘Home delivery’ (β_{11}), was positive and statistically significant, which indicates that consumers prefer to receive their online order at home. For the attribute ‘Time and Speed’, the coefficients of the dummy variables ‘Express delivery (1-2 days)’ (β_{22}), ‘Next day delivery’ (β_{23}), ‘Delivery at a specific time-window’ (β_{24}), and ‘Saturday morning delivery’ (β_{25}) were all positive and statistically significant. This indicates that respondents prefer all different levels of ‘Time and Speed’ relative to the reference level ‘standard delivery (3-7 days)’. The coefficients of the dummy variables for ‘Track and Trace’, ‘Notification messages for order status (email/sms/app)’ (β_{32}) and ‘Notification messages for the expected day and time of delivery’ (β_{33}), were both positive but the latter was statistically significant whereas the former is at the border line of significance, which indicates that consumer prefer having these two attributes relative to the reference level but consumers are more interested in receiving ‘Notification messages for the expected day and time of delivery’ (β_{33}). The coefficients of the dummy variables for ‘Value-Added-Services’ such as ‘Indemnity in case of unreliable delivery service (time, cost, etc.)’ (β_{41}) was positive but statistically non-significant, which indicates that consumers are not interested in receiving such an option. However, the coefficients of the next two dummy variables, ‘Cash on delivery’ (β_{42}) and ‘Possibility to change shipment route in case of consumer’s absence from home’ (β_{43}) were negative and only the former was statistically significant relative with the reference level of ‘Return Service’. This indicates that consumers are not interested in paying ‘cash-on delivery’ when they receive their online order. Finally, the coefficient of the continuous variable of ‘Delivery cost’ was positive and statistically significant which shows that consumers are willing to incur extra cost in order to receive their online order quicker and with other positive factors. This is an interesting point to investigate further, considering the negative coefficients that they were found to alternatives specific constants for each service alternative.

Table 1 Estimation results for the random utility model

Variable Number	Variable Name	Coefficient estimate	Standard Error	z-statistic
1	Economy Service (ASC_{ES})	-1.29***	0.15	-8.2123
2	Standard Delivery Service (ASC_{STD})	-2.72***	0.20	-13.5790
3	Special Delivery Service (ASC_{SPD})	-4.98***	0.32	-15.4882
4	Home delivery (β_1)	0.62***	0.13	4.7117
5	Express delivery (1-2 days) (β_{22})	1.23***	0.20	6.3040
6	Next day delivery (β_{23})	1.05***	0.17	6.2002
7	Delivery at a specific time-window (β_{24})	0.91***	0.13	6.7917
8	Saturday morning delivery (β_{25})	1.03***	0.21	4.8415
9	Notification messages for order status (email/sms/app) (β_{32})	0.26	0.15	1.7040
10	Notification messages for the expected day and time of delivery) (β_{33})	0.39*	0.18	2.2342
11	Indemnity in case of unreliable delivery service (time, cost, etc.) (β_{41})	0.11	0.19	0.5576
12	Cash on delivery (β_{42})	-0.26*	0.11	-2.3595
13	Possibility to change shipment route in case of consumer's absence from home (β_{43})	-0.23	0.13	-1.7837
14	Delivery cost (β_5)	1***	0.06	16.8934

***($p < 0.001$) *($p < 0.05$) borderline significant

From the table above, the observed variables of each utility function for each of the three Alternative Services (*Economy Service, Standard Delivery Service and Special Delivery Service*) can be formed as follows:

The utility function of Service Alternative 2, that is 'Economy Service' is as:

$$V_{ES} = -1.29 + 0.62 \cdot DP1 + 0.91 \cdot T\&S4 + Cost \quad (5.1)$$

The utility function of Service Alternative 3, that is 'Standard Delivery Service' is as:

$$V_{StS} = -2.72 + 0.62 \cdot DP1 + 1.23 \cdot T\&S2 + 1.05 \cdot T\&S3 + 0.91 \cdot T\&S4 + 0.39 \cdot T\&T3 - 0.26 \cdot VAS2 + Cost \quad (5.2)$$

The utility function of Service Alternative 4, that is 'Special Delivery Service' is as:

$$V_{SpS} = -4.98 + 0.62 \cdot DP1 + 1.23 \cdot T\&S2 + 1.05 \cdot T\&S3 + 0.91 \cdot T\&S4 + 1.03 \cdot T\&S5 + 0.39 \cdot T\&T3 - 0.26 \cdot VAS2 + Cost \quad (5.3)$$

Overall, the chi-squared goodness-of-fit test indicated that the model was significant and provided an adequate fit to the data, $\chi^2=1508.2$, $p < 0.001$. This is also confirmed by McFadden's pseudo R^2 , which was equal to 0.386 and within suggested limit values (Hensher & Stopher, 1979).

CONCLUSIONS

The focus of this research paper was to investigate the key attributes in individual decision making for which delivery service is most appropriate to choose for his/her online order. Using Stated Preference Experiments, the alternative specific constants for each delivery service alternative were estimated. Results have shown that consumers are not inclined to use an expensive delivery service relative to the 'Free Delivery Service'. However, the coefficient estimates of the dummy variables have shown that most of them were significantly different from zero at the usual of 5% or 10% levels of significance. It will be interesting to investigate further the multinomial model estimated in this paper including socioeconomic factors as well as psychometric indicators in order to get more precise results.

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Session 21:
Intelligent Systems in Transportation
(ENIRISST workshop)
chair: Dimitrios Dimitriou

A Blockchain Technology implementation for Cold Supply Chains

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Abstract

Blockchain is considered a cutting-edge technology, quickly reaching a maturity phase with more and more applications emerging in the business sector. The two main benefits are data integrity and its capability of applying Smart Contracts. Digital Supply Chains (SC) could benefit from the Blockchain Technology (BCT) in order to secure data sharing across multiple stakeholders however, this potential is still untapped due to the challenging integration of BCT. This need for integration along with the use of other prominent digital technologies like the Internet of Things (IoT), propel novel business models that should be further examined. We propose the integration of BCT in the food and beverage supply networks with a special focus on the cold SC ecosystem in order to increase traceability in a farm-to-fork-perspective. In this context, a cold supply chain business model was designed using the Hyperledger Fabric while Smart Contracts ensure the execution of transactions among the stakeholders.

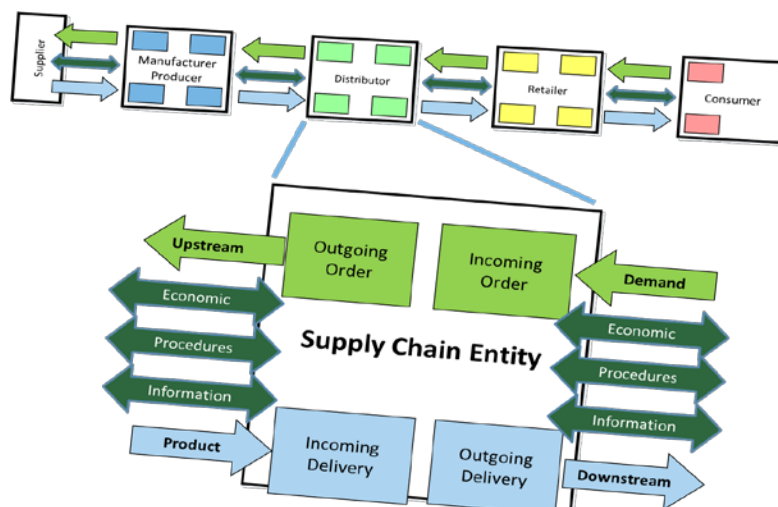
KEYWORDS

digital supply chains, cold supply chains, blockchain, smart contracts.

INTRODUCTION

The Supply Chain (SC) ecosystem involves the SC stakeholders (n-tier suppliers, producers, distributors, wholesalers, retailers and consumers) and the SC flows that are used in order to enable the transactions among the stakeholders. The information, the product, the procedures and the economic flows are the typical SC flows and transactions are executed either downstream from the suppliers to the consumers or upstream from the consumers to the suppliers (Figure 1).

Figure 1. The stakeholders and the basic flows of the supply chain ecosystem



The cold SC focuses on the movement of refrigerated products that should be transported and stored in the SC ecosystem. Food and beverage industry is heavily involved at the cold SC network as most of the commodities involve a refrigeration stage (cooling or freezing) in order to maintain food quality at a desired level (Bechtsis et al., 2019). On the other hand, SC stakeholders have as a common goal to make profit and increase the overall value of their network. This forces the use of technologies that enable the end-to-end visibility in the SC ecosystem in order to ensure the

quality of their products and provide added value by using the network's services but on the same time increase profit by minimizing the SC's inventories.

Blockchain technology (BCT) focuses on security issues as blockchain is involved at the creation of electronic currency. The Bitcoin cryptocurrency is a blockchain implementation that penetrated at the economic transactions and was thoroughly discussed by Nakamoto (2008). The wide and fast adoption of the bitcoin and its unique security features created a set of innovative applications that benefit from the blockchain's inherent security and its decentralized nature. The basic element of the BCT is the block structure and every block in the chain includes the address of the previous block, while all peer users have a copy of the chain. In order to insert a single block to the chain you have to check the integrity of the chain's structure and have a consensus from the peer nodes to the fact that the new entrance is valid. Blockchain technology (BCT) could provide end-to-end visibility and traceability and this comes with an inherent security mechanism that safeguards the stored information and ensures reliable transactions among the SC stakeholders. Knowledge sharing and transaction tracking across stakeholders improves visibility, accountability and traceability while the use of real-time smart contracts enhances the overall efficiency of the logistics operations [Banerjee, 2018]. Blockchain application could be divided in three major categories (i) public blockchains where all the nodes act as peers and anyone can join the network, (ii) private blockchains where only authorized users can take part; and (iii) federated blockchains where authorized users can use the federated blockchain backbone and third party users can monitor the outputs by using nodes that commit transactions, nodes that process the transactions and nodes that can only monitor the outputs.

At this context we present a blockchain implementation for cold SCs at the food and beverage industry that automates the stakeholders' transactions using smart contracts. Our implementation was based on the stable IBM's Hyperledger Fabric platform and presents a two-stage cold SC that moves perishable agrifood products. Hyperledger Fabric could be considered as a permissioned network (Baliga, 2018) where all transactions use public key cryptography and could be easily transformed at a federated blockchain environment. Section 2 describes the technical description and the business model of our implementations while section 3 includes conclusions and future work.

MATERIALS AND METHODS

The Food SC involves all the farming processes from farm to fork as the agricultural commodities are moving from farmers to producers, from producers to wholesalers and retailers until they finally arrive to the consumer. The food industry was chosen as food commodities are critical for human health and food scandals have proven that food traceability is crucial for security issues (Yakavenka et al., 2018). Foth (2017) examines BCT and discusses BCT using the example of the Australian meat industry and proposes the BeefLedger architecture. Lu and Xu (2017) trace food commodities under the OriginChain architecture and cooperates with Chinese e-commerce retailers. After carefully examining the business processes of the aforementioned Food SCs, we propose the use of Hyperledger Fabric for implementing a model of the cold SC. At our case study we implement a private blockchain and every distinct step of the process creates blocks that store the critical information in the blockchain infrastructure. Smart IoT devices are proposed at the field level in order to provide the necessary information about the agricultural products' status as this process minimizes the human data entry errors by automating the transactions.

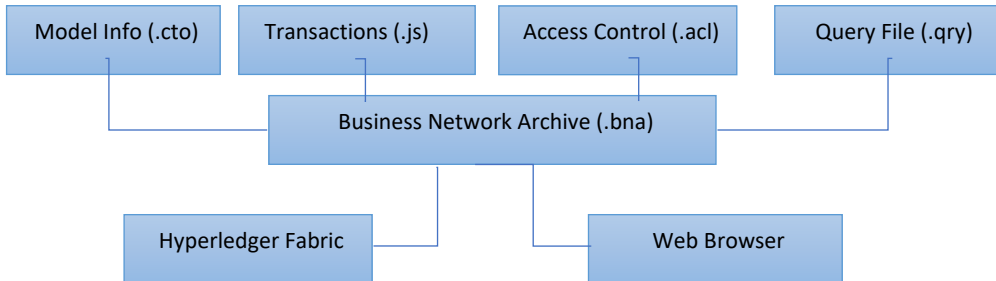
Technical Description

A virtual machine was used for the installation of the Hyperledger Fabric software and the fabric composer was used at the time of development. Hyperledger is an incubator platform for the BCT, the Hyperledger Fabric is the Distributed Ledger Technology (DLT) Framework for businesses that uses the Hyperledger Composer as a tool for creating applications (*Figure 2*) and finally the chaincode is used as a smart contract language for the implementation of the smart contracts.

The Hyperledger Fabric includes the following structural and functional elements (i) Organisations, (ii) Identities, (iii) Ledger, (iv) Certificate Authority, (v) Membership Service Provider, (vi) Peer nodes, (vii) Ordering Service and Nodes, (viii) Chaincode and (ix) Assets. In order to create the business model and the overall processes Hyperledger uses Identities for creating the SC stakeholders (Participants) and Assets for every added value object at the SC network. For executing the transactions, the Hyperledger Fabric implements the transactions' flow and the consensus procedures that enable the execution of a transaction in three distinct steps. To begin with, a transaction request is created and is sent to all the peer nodes for approval. The peer nodes are executing the code and create a reply, while the creator of the request propagates the answers to the ordering service and the latter orders the requests, creates the blocks that include the transaction and distributes the blocks to the peer nodes. When a peer node receives the new block it processes the transactions in a prespecified order, examines whether they are valid (they are accepted from the authority that they are issued, they have the proper timestamp, valid credentials etc) and checks if the previous state

of the ledger is compatible with the new state that includes the proposed transaction. Only when everything is sound and valid, the transaction is stored at the ledger. In any other case the transaction is marked as invalid and it is not inserted at the ledger. It should be mentioned that Hyperledger Fabric is using channels; channels have distinct ledgers and participants could interoperate with multiple channels and independently communicate with the participants of each channel.

Figure 2. Hyperledger’s general architecture



We implemented a two-stage cold SC model with the IBM’s Hyperledger solution. At the proposed Business Domain Model (Figure 3), participants are the Hyperledger’s entities, assets represent any kind of value at the network and have specific properties, transactions can be dynamically executed and alter the assets properties and events are used to inform the entities about the changes of the ecosystem. The chaincode defines the assets’ and transactions’ structure and the ledger safely stores and tracks all the assets’ transactions. Participants can initiate the transactions and the peers keep the ledger data synchronized while the orderers are responsible for the communication activities and for the distribution of the transactions. We have two types of peers the anchor peers that are discoverable and receive the blocks and update other peers and the endorsing peers that validate the transactions and can accept or reject a transaction request and execute the chaincode but do not save the state to the ledger.

Figure 3. Script sample for creating part of the business model (.cto file)

```

2
3  abstract participant Suppliers_main identified by supplierID {
4      o String supplierID
5      o ContactInfo ContactInfo
6  }
7
8  abstract participant Retailers_main identified by retailerID {
9      o String retailerID
10     o ContactInfo ContactInfo
11 }
12
13 participant Supplier extends Suppliers_main {
14 }
15
16 participant Retailer extends Retailers_main {
17 }
18
19 concept ContactInfo {
20     o String CompanyName
21     o String email
22     o Integer phone
23 }
  
```

The ledger for all the critical blockchain transactions was built at the levelDB database (create and retrieve rights are activated while update and delete rights are deactivated) while the CouchDB database was used for storing the state of all the assets (properties and values) in order to use complex queries for information retrieval. Peers communicate with the CouchDB for the state management of all the assets and with the levelDB for retrieving information about the transactions’ data.

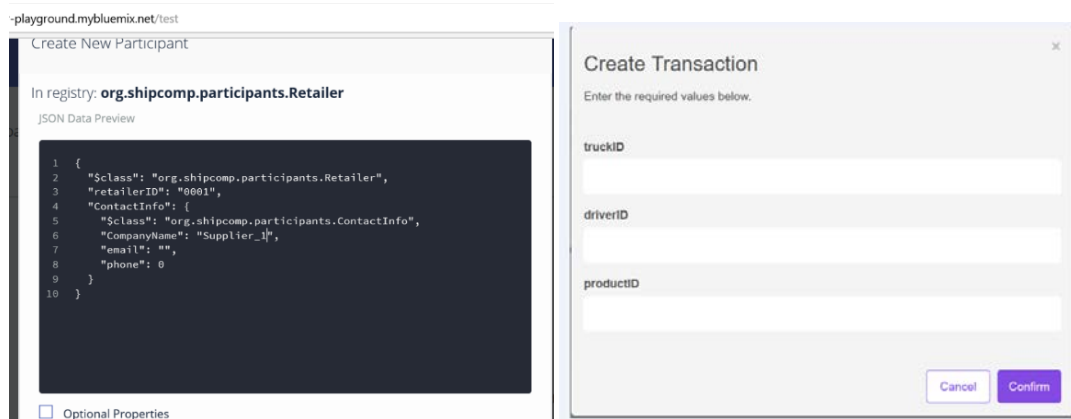
The simulation model

At the implementation stage, participants receive a credential’s card (for authentication & authorization) and could either create nodes or just communicate with the BC network. The platform’s administrator inserts at the network (i) suppliers and retailers for implementing the two stage SC, (ii) products, trucks and drivers for the daily activities, and (iii) transactions and events for implementing the business logic of the network. Finally, a smart contract is implemented in order to watch the truck’s temperature value and in case the temperature is not at the predefined limits the product’s value is decreased as this could change its organoleptic properties. The transactions could be monitored by all

participants as critical information is safely stored at the Ledger (both at levelDB and CouchDB) and the stakeholders can retrieve information from the ledger.

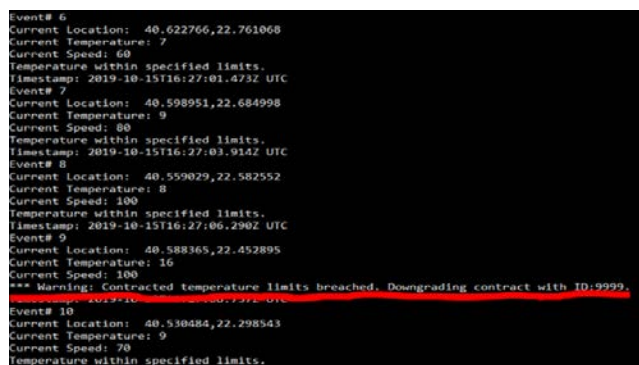
The use case scenario involves the administrators that can add participants to the network, the participants that receive their credentials and establish relationships, the created transactions that monitor the participants and the assets (Figure 4), the smart contracts that receive the feedback from the transactions in order to automatically execute the application's business logic and the flows of information that are stored at the either at the levelDB or at the CouchDB databases according to the security levels and the complexity of the datasets. For our model we created the Supplier and the Retailer Participants, the Product, the Driver and the Track Assets, the Product Transportation transaction that monitors the product's movement from the Supplier to the Retailer using the Truck and the Inform Supplier and Inform Retailer events for communicating all the changes to the SC ecosystem.

Figure 4. Create participants and transactions at the playground interface



Finally, a smart contract constantly checks the value of the truck's temperature in order to safeguard the products quality. In case the temperature is not at the prespecified limits the final price of the product is automatically lowered according to the initial agreement (Figure 5).

Figure 5. Create participants and transactions at the playground interface



CONCLUSIONS

The use of BCT could increase end-to-end visibility and accountability at the SC ecosystem. We propose the use of the Hyperledger Fabric network for implementing the business model of a food and beverage SC while focusing on the cold SC scenario. A full scale two-stage business model is created at the Hyperledger Fabric with the Supplier and the Retailer Participants. Products move downstream from the Supplier to the Retailer using Trucks and Smart Contracts monitor the movement for assuring the quality of the products during the transportation phase. In case the truck's fridge temperature is not at the predefined limits, the smart contract automatically decreases the Product's value according to the predefined agreement. This automates the procedures at the SC ecosystem and provides end-to-end visibility and accountability.

Our pilot includes a two stage SC model and should be further expanded to include all the participants in a SC ecosystem. As a result, a full-scale business model is among our short-term plans that could capture all the transactions at the SC ecosystem along with a user-friendly interface for the real time monitoring of all the transactions.

ACKNOWLEDGEMENT

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Session 22:
Multiple Criteria Decision Analysis
chair: Panagiotis Mitropoulos

Portfolio Productivity Performance Assessment Using a Sequential Malmquist–Luenberger Index

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Abstract

Most studies to measure portfolio productivity changes are using the Malmquist index. However, Malmquist index has the possibility of producing biased productivity measures because it might not consider the features of technology appropriately. This stands because it is not uncommon to observe technical regress, while in general the technology in financial markets at least remains unchanged. Malmquist–Luenberger index suggests an alternative measure of portfolio productivity measurement. However, the Malmquist–Luenberger productivity index presents the same limitation to Malmquist index, ignoring past technology in the evaluation. To overcome the drawback of Malmquist–Luenberger model on portfolio productivity gauging, this study employs a Sequential Malmquist–Luenberger productivity index which merges the concept of the sequential reference production sets and the concept of the directional distance function. Based on a balanced panel dataset of Greek Equity Mutual Funds over the period 2003–2014, where the Greek market is characterized by major fluctuations, this study monitors the static portfolio efficiency and the dynamic portfolio productivity change of Greek mutual fund industry. The portfolio performance over time is decomposed into the contribution of efficiency change and technological change. Furthermore, it lets investors to measure both the degree that a portfolio improves or worsens its efficiency in return and risk and the effect of the innovation in financial markets on the portfolio productivity.

KEYWORDS

Sequential Malmquist–Luenberger, DEA, Directional Distance Function, Productivity index, Efficient portfolios

INTRODUCTION

Besides the traditional portfolio performance indices, a growing body of studies has already used frontier methods as a tool for portfolio benchmarking comparisons in investment analysis. Based on the assumption that return is desirable while risk is to be avoided these studies have applied non-parametric efficiency measurement techniques, most prominently data envelopment analysis (DEA) (e.g. Morey and Morey, 1999). Rather than focusing on standard DEA performance measures, some studies adopt the directional distance function. Unlike the traditional DEA models that optimize solely either in a return augmentation or in a risk contraction orientation, the directional distance function simultaneously optimizes in both orientations as much as it is technologically feasible. Briec et al. (2004) and Briec and Kerstens (2009) integrate the shortage function (Luenberger, 1992) to measure portfolio efficiency in a mean-variance framework. Pendaraki (2015) applying quadratic directional distance function, finds that biased fund efficiency estimation is produced when a standard input DEA-BCC approach (Banker et al., 1984) is followed.

There are relatively few studies that estimate portfolio performance change. In general, these studies use the conventional non-parametric Malmquist index (MI) (Caves et al., 1982) with the standard DEA approach which might provide biased estimates of fund performance. Chambers (2002) introduces the Luenberger productivity indicator which is based on the directional distance function. Brandouy et al. (2010), integrate the shortage function into a Luenberger productivity indicator to evaluate portfolio productivity change over time in a mean-variance framework. Boussemart et al. (2003) prove that MI overestimates productivity change as compared to a Luenberger productivity indicator.

This study, to fill a gap in the literature, suggests as an alternative tool of portfolio performance change measurement over time, a Malmquist–Luenberger productivity index (ML) introduced by Chung et al. (1997), who models joint production of desirable and undesirable outputs. While MI measures in either risk or return orientations, ML productivity index can simultaneously contract risks and expand returns. However, the ML productivity index presents the same limitation as MI, ignoring past technology in the evaluation. Moreover, when ML index is computed, in the same way as MI, may presents a problem of infeasibilities due to the shifting of frontier between two time periods (Briec and Kerstens, 2009).

To overcome these drawbacks, this study employs the sequential reference production sets of Tokens and Vanden Eeckaut (1995) to estimate the Malmquist-Luenberger productivity index through the methodology of Oh and Heshmati (2010). As far as we know, this is the first work of its kind in portfolio productivity performance appraisal over time. The rest of the paper is organized as follows. Section two gives some useful notation on distance function and the Sequential Malmquist-Luenberger productivity index employed. Section three describes both the data set and the empirical results of the study. Finally, section four concludes the paper.

METHODOLOGY

A Sequential Malmquist-Luenberger Productivity Index

Let us assume a sample of $j (= 1, 2, \dots, n)$ financial assets with m risk variables $x_{ij}, i = 1, 2, \dots, m$ and s output-like variables $y_{rj}, r = 1, 2, \dots, s$ to measure portfolio efficiency. The technology set is defined as $S = \{(x, y) : x \text{ can produce } y\}$. The directional distance function which evaluates the performance of portfolios by measuring the distance between a portfolio and an optimal portfolio projection on the efficient frontier in the direction of vector β may be calculated for unit $o \in \{1, 2, \dots, n\}$ as:

$$\bar{D} = \max \beta \text{ s.t. } \sum_{j=1}^n \lambda_j y_{rj} \geq y_{ro} + \beta |y_{ro}| \quad r = 1, 2, \dots, s, \quad \sum_{j=1}^n \lambda_j x_{ij} \leq x_{io} - \beta |x_{io}| \quad i = 1, 2, \dots, m, \quad \sum_{j=1}^n \lambda_j = 1, \quad \lambda_j \geq 0, \quad j = 1, 2, \dots, n.$$

The Sequential Malmquist-Luenberger productivity index (SML) merges the concept of the sequential reference technology sets and the concept of the directional distance function. This is accomplished through the construction of reference technologies from observations of the concurrent and all previous examined periods. Thus, the sequential technology set can be represented through $S^{1,t}(x, y) = U_{s=1 \text{ to } t} S^{1,t}(x, y)$.

A Sequential Malmquist-Luenberger productivity index between time-period t and $t+1$ is defined on the sequential technology set by $SML_t^{t+1} = \left[\frac{1 + \bar{D}^t(\chi^t, y^t)}{1 + \bar{D}^t(\chi^{t+1}, y^{t+1})} \frac{1 + \bar{D}^{t+1}(\chi^t, y^t)}{1 + \bar{D}^{t+1}(\chi^{t+1}, y^{t+1})} \right]^{1/2}$

The SML can be decomposed into sequential efficiency change (SEC) and sequential technical change (STC) (Chung *et al.* 1997):

$$SML_t^{t+1} = \underbrace{\frac{1 + \bar{D}^t(\chi^t, y^t)}{1 + \bar{D}^{t+1}(\chi^{t+1}, y^{t+1})}}_{SEC^{t,t+1}} \underbrace{\left[\frac{1 + \bar{D}^{t+1}(\chi^t, y^t)}{1 + \bar{D}^t(\chi^t, y^t)} \times \frac{1 + \bar{D}^{t+1}(\chi^{t+1}, y^{t+1})}{1 + \bar{D}^t(\chi^{t+1}, y^{t+1})} \right]^{1/2}}_{STC^{t,t+1}}$$

The calculation of SML and its decompositions requires the computation of four distance functions for each index. Two of them utilize a contemporaneous and a sequential technology set, while the other two utilize the intertemporal and a sequential technology set (see Oh and Heshmati, 2010). The SML denotes productivity improvements (decreases) if it takes value greater (less) than one. Through this methodology the portfolio performance change can be appropriately charged to both fund strategies (SEC) and market evolution (STC).

EMPIRICAL RESULTS

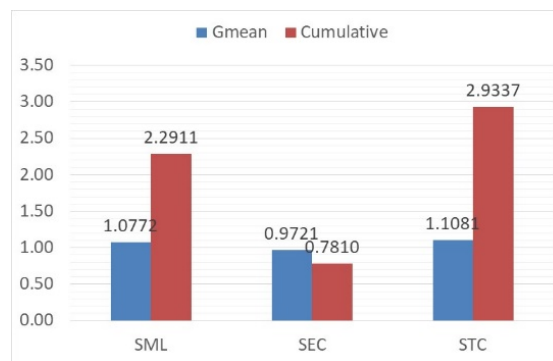
Data and Variables

The sample used in the present study is collected from the Hellenic Fund and Asset Management Association. It consists of daily net asset value data of 21 domestic equity mutual funds over a period running from January 2003 to December 2014. This period encompasses both bull and bear market years with negative returns and high volatility. A total of 63,000 observations is generated with non-missing values. For each of the 21 funds, we have calculated and annualize their yearly continuous compounding daily returns and their 2nd order upper partial moments as output-like variables. We also add in the model the Semi Deviation and Downsize Frequency of returns as input-like variables.

Fund Market Performance Change and its Components

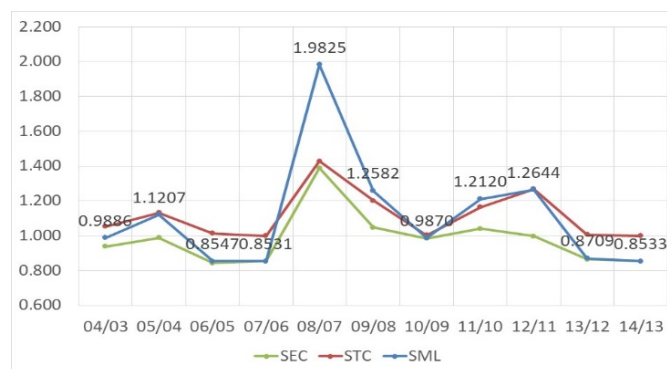
Figure 1 reports the static feature for mutual fund market SML index and its decompositions from 2003 to 2014. Mutual funds experienced a progression in the evolution of their performance across the period. On average, this progression is explained mainly by technological innovation while there is a slight regression in the evolution of efficiency. In the examined period the geometric mean performance change (Gmean) is 7.72% per year, while the cumulative performance change of funds in 2014 increased by 2.2911 times compared to 2003.

Figure 1 The mean performance change and the cumulative performance change of funds



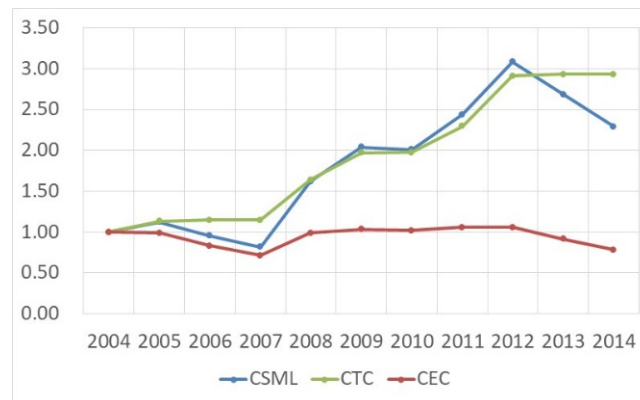
The trends of the mean performance change in Greek equity mutual fund market from 2003 to 2014 is exhibited in Figure 2. Overall, the course of the SML productivity index and its main drivers by year, marked by instability mainly due to multi-year European debt crisis since the end of 2009 and the deep government-debt crisis faced by Greece in the aftermath of the global financial crisis of 2007–08 started in late 2009 and, as of December 2014, was still ongoing. The periods 2005-07, 2008-10 and 2011-12, funds' performance as it presented by SML index, declines sharply. This is caused by the compound effect of loss of funds efficiency and technical regression, as signalled by deterioration of SEC and STC indices.

Figure 2 Trends of the funds' average performance change



To observe the trends in funds' performance change comparatively, the cumulative productivity indices which measure the change from the first period, are presented in Figure 3. From 2003 till 2017, funds' performance change, as it presented by CSML index, decline gradually, caused by loss of funds efficiency. The period 2007- 12, there is improvement in funds' accumulated performance, mainly due to technical progress (CSTC) rather than to efficiency change (CTEC) that exhibits stagnation. Moreover, after 2012 the funds' performance declines sharply, due to deterioration of funds' efficiency and the fact that technical change has no effect.

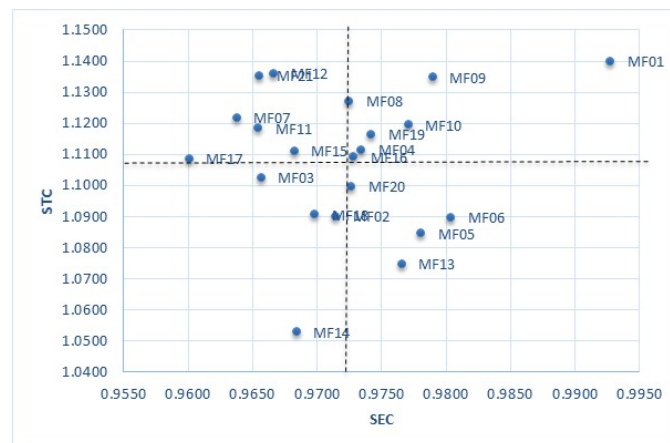
Figure 3 Trends of the funds' cumulative performance change and its components



Decomposition Analysis of Funds' Performance Change

Based on their drivers of performance change (SEC and STC), the examined mutual funds are categorized into four groups according to their place in a scatter diagram, which is divided into four quadrants defined by their average values.

Figure 4 Funds productivity change drivers



In the upper-right quadrant belong the best funds (SEC > 0.9721, STC > 1.1081). In the upper-left quadrant are catching-up but less innovative funds (SEC > 0.9721, STC ≤ 1.1081). In the lower-right quadrant are lagging but more innovative funds (SEC < 0.9721, STC > 1.1081). Finally, in the lower-left quadrant are the lagging and less innovative funds (SEC ≤ 0.9721, STC ≤ 1.1081).

Performance of Funds Before and During the Financial Crisis

This section investigates the differences in funds' performance in two periods, namely the period before the current financial crisis, dated from 2003 until 2007, and the period during the financial crisis, dated from 2008 until 2014. In Table 1 we provide the mean values of the SML index and its components differentiating between the two periods. In first sub-period, the minor technical change improvement cannot counterbalance the deterioration in terms of efficiency change, and this drives the decrease in performance. In the second sub-period, funds' performance improved. This is caused by the compound effect of improvement in funds efficiency and technical progress. A Mann–Whitney U test verifies that the differences between the observed indexes are statistically significant between the two examined periods.

Table 1 Overview of the results of the SML index and its components before and during the crisis

	2003-2007	2008-2014	MWU- p value
SML	0.9481	1.1587	.000
SEC	0.9041	1.0133	.000
STC	1.0487	1.1435	.000

CONCLUSIONS

This study suggests the Sequential Malmquist-Luenberger index, as a new measure of portfolio performance change measurement, offering an alternative perspective and characterization of the portfolio performance gauging. Based on this index, it estimates the changes in the relative positions of portfolios with respect to the efficient frontier, as well as the subsequent shifts of this frontier over the examined period. Furthermore, we evaluate portfolios performance change due to manager strategies and the evolution of financial markets. The results of this study indicate that technical changes contribute at most to mutual fund performance change while efficiency changes have less effect on performance improvement. Moreover, results show that, despite the crisis in effect, funds' performance progress has been taken place. Obviously, the proposed index needs validation. Thus, further research is going to include its comparison with MI and standard ML index.

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Migrations and Quality of Life: Multi-Criteria Approach in Exploring the Causal Link

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Abstract

Migration and its consequences represent an indispensable feature of the modern age, with the ever-increasing number of migrants globally. There is a great interest in the world about migration issues. Migration, with natural population growth, directly affects the economic, social, cultural, demographic developments, as well as the human capital of a particular region. The existing literature mostly accentuates the impact of economic factors, educational opportunities, job prospects, higher life satisfaction, and better health care as the main factors causing migration. However, few studies examine the link between various aspects of the overall quality of life and migratory movements. In most cases, potential migrants expect better job opportunities in the new environment, but also a better quality of life in every respect. Therefore, this paper aims to examine the link between the overall quality of life and migration. The quality of life assessment was conducted on a sample of 22 European countries, using 27 socioeconomic and environmental indicators grouped into 10 quality of life categories. Aggregation of data by groups was performed using SAW (Simple Additive Weighting) approach, while the determination of the overall quality of life was performed using PROMETHEE method (Preference Ranking Organization METHod for Enrichment of Evaluations). By performing a correlation analysis between the estimated quality of life and the crude net migration rate, it was observed that there was a significant, moderately strong positive correlation.

KEYWORDS

Quality of life, Migrations, SAW, PROMETHEE.

INTRODUCTION

According to Bobek (2020), migrants can be categorized into three groups: highly-skilled mobile professionals, low-skilled labour migrants and 'in the middle' migrants which are young and well educated. When considering the effects of migration, two views emerge, on the one hand, there are perceptions that immigration flows increase crime and harm the sustainability of public finances, while on the other hand, there are perceptions that foreign workers contribute to mitigating the negative impact of demographic dynamics on the financial sustainability of pension and social system (Morettini et al. 2012). However, recent studies indicate that countries with a positive net migration balance achieve higher productivity due to positive impact on labour market flexibility, dependency ratio, aggregate demand and net fiscal contribution (Dumont & Liebig, 2014; Pettinger, 2015). There is evidence that migration enables the efficient use of place premiums because people are often more productive if they move to a new location, even if their work skills and personal characteristics do not change (Somin, 2017).

Various researches have examined the factors that motivate migratory movements. Tiebout (1956) set up a model according to which people can express their preferences for government services by "foot voting", that is, by leaving their place of residence and moving to another place with satisfactory government services. In addition to government services, various socioeconomic factors have an impact on the preferences of residents, and changes in these factors also affect migration patterns (Higa et al., 2019). Formerly, financial benefits were considered to be the most important factor influencing relocation and that migration occurs as a result of people deciding to relocate to places where they get better jobs and higher earnings (Bobek, 2020). Greenwood et al. (1991) have discovered that both amenities and economic opportunities represent a significant factor of migrations. Williams and Jobes (1990) examined whether the migrations are motivated by economic opportunities, by the quality of life or by some combination of the two and concluded that economic opportunities facilitate the migration but are not the primary reason for migration. Several other researches revealed a positive impact of the quality of life on population inflow (Ariu et al., 2016; Higa et al. 2019; Faggian et al., 2012). World Health Organization defines the quality of life as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHOQOL, 2020, p.1). Quality of life represents a current research topic, mainly focused on creating composite indices based on which evaluation is performed (Navarro-Azorín and Artal-Tur, 2015).

Therefore, the main objective of the paper is to evaluate the quality of life in 22 European countries and to examine its association with the net migration balance. The main research question is whether the increase in the quality of life in European countries leads to an increase in the net migration balance.

This paper aims to contribute to the existing literature on quality of life and its association with migrations. The paper is structured as follows. After introductory notes, data and methodology will be presented, followed by the results of the analysis. Concluding remarks will be offered at the end.

DATA AND METHODOLOGY

To determine the relationship between quality of life and migrations in the selected European countries, the data on 27 socioeconomic and environmental indicators grouped into 10 quality of life categories were used.

Table 1. Indicators and categories of quality of life

Category	Life satisfaction	Housing	Income	Labour market	Education
Indicators	-Self-reported life satisfaction	- Dwellings without basic facilities - Housing expenditure - Rooms per person	- Household net wealth - Material living conditions	- Labour market insecurity - Employment rate - Long-term unemployment rate - Personal earnings	- Population by educational attainment - Student skills - Years in education
Category	Environment	Civic engagement, governance and basic rights	Health	Economic security and physical safety	Work-Life Balance
Indicators	- Air pollution - Water quality	- Stakeholder engagement for developing regulations - Voter turnout - Participation in formal or informal voluntary activities or active citizenship - Gender pay gap	- Self-reported health - Life expectation	- Feeling safe walking alone at night - Homicide rate - Inability to face unexpected financial expenses	- Employees working very long hours - Time devoted to leisure and personal care - Participation in any cultural or sport activities

Data were collected from OECD's Better Life Index database (OECD, 2020), the Eurostat's Quality of life database (Eurostat, 2020) and from World Happiness Report 2018 (Sachs et al., 2018). Aggregation of data by groups was performed using SAW (Simple Additive Weighting) approach, while the determination of the overall quality of life was performed using PROMETHEE method (Preference Ranking Organization METHod for Enrichment of Evaluations). For the determination of the weights, necessary for the application of the PROMETHEE method, standard deviation method was applied.

SAW approach

The SAW method can be considered as one of the simplest method for solving multi-criteria decision-making problems developed by Churchman and Ackoff (1954). The essence of the method is in the evaluation of utility for the decision maker, which can be represented by the following equation:

$$u_i(x) = \sum_{j=1}^n w_j r_{ij}(x) \quad (1)$$

where:

$u_i(x)$ – utility of the i^{th} alternative, $i=1,2,...m$

w_j – weighting coefficient of the j^{th} criteria, $j=1,2,...n$

$r_{ij}(x)$ – normalized attribute value

Attribute normalization is performed by applying linear normalization, and before applying the algorithm, it is necessary for the decision maker to determine the vector of weighting coefficients.

Method consist of three steps:

- 1) Normalization of the decision matrix,
- 2) Application of criteria weights to normalized decision matrix and
- 3) Summation of weighted values for each alternative.

Standard deviation method

According to the standard deviation method, the weight coefficients of the criteria are determined through four steps (Jahan & Edwards, 2013):

Step 1: Determining the elements of the normalized decision matrix r_{ij} using the relation for linear normalization:

$$r_{ij} = \frac{x_{ij} - x_{ij}^{\min}}{x_{ij}^{\max} - x_{ij}^{\min}} \quad (2)$$

where $x_{ij}^{\max} = \max_i x_{ij}$ and $x_{ij}^{\min} = \min_i x_{ij}$, $i = 1, 2, \dots, m$, $j = 1, 2, \dots, n$.

Step 2: Determining the mean value of the attribute using the relation:

$$\bar{r}_{ij} = \frac{\sum_{i=1}^m r_{ij}}{m}, \quad j = 1, 2 \dots n \quad (3)$$

Step 3: Determining the standard deviation of the attribute:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^m (r_{ij} - \bar{r}_{ij})^2}{m}}, \quad j = 1, 2 \dots n \quad (4)$$

Step 4: Determination of weight coefficients of the criteria using additive normalization:

$$w_j = \frac{\sigma_j}{\sum_{j=1}^n \sigma_j} \quad (5)$$

PROMETHEE method

PROMETHEE method was originally introduced by Brans and presented at the conference in 1982 (Brans and De Smet, 2016). There are various version of the PROMETHEE methods, whereby in this paper PROMETHEE II approach will be applied. PROMETHEE II approach is based on a pair-wise comparison of the alternatives according to different criteria (Behzadian et al, 2010)

To formulate the decision making problem a set of alternatives $A = \{a_1 \dots a_m\}$ and a set of criteria $G = \{g_1 \dots g_n\}$ is considered (Brans and De Smet, 2016).

The preference of an alternative a_i over an alternative a_j for each criterion g_k is determined in the first step:

$$d_k(a_i, a_j) = g_k(a_i) - g_k(a_j) \quad (6)$$

In the next step the transformation of the results of this pairwise comparison into a preference degree is performed based on the preference function P_k (Sarrazin et al., 2018).

$$P_k(a_i, a_j) = P_k[d_k(a_i, a_j)] \quad (7)$$

$$0 \leq P_k(a_i, a_j) \leq 1 \quad (8)$$

Based on the shape of the selected preference function (see Brans et al. (1986)) decision maker may express the indifference threshold q_k and the preference threshold p_k for each criterion. The global preference of a_i over a_j , $\pi(a_i, a_j)$, is obtained in the next step, and represents a weighted sum of all preferences $P_k(a_i, a_j)$, wherein w_k is the relative importance of the j^{th} criterion.

$$\pi(a_i, a_j) = \sum_{k=1}^j P_k[d_k(a_i, a_j)] \cdot w_k \quad (9)$$

$$w_k \geq 0, \sum_{k=1}^j w_k = 1 \quad (10)$$

The calculation of outranking flows of each alternative is performed in the next step, where φ^+ and φ^- denote the positive flow score and the negative flow score, respectively.

$$\varphi^+(a_i) = \frac{1}{n-1} \sum_{x \in A} \pi(a_i, x) \quad (11)$$

$$\varphi^-(a_i) = \frac{1}{n-1} \sum_{x \in A} \pi(x, a_i) \quad (12)$$

The final step consist in calculation of the net outranking flows which are defined as the balance between the positive and the negative outranking flows (Kabir & Sumi., 2014):

$$\varphi(a_i) = \varphi^+(a_i) - \varphi^-(a_i) \quad (13)$$

RESULTS OF THE ANALYSIS

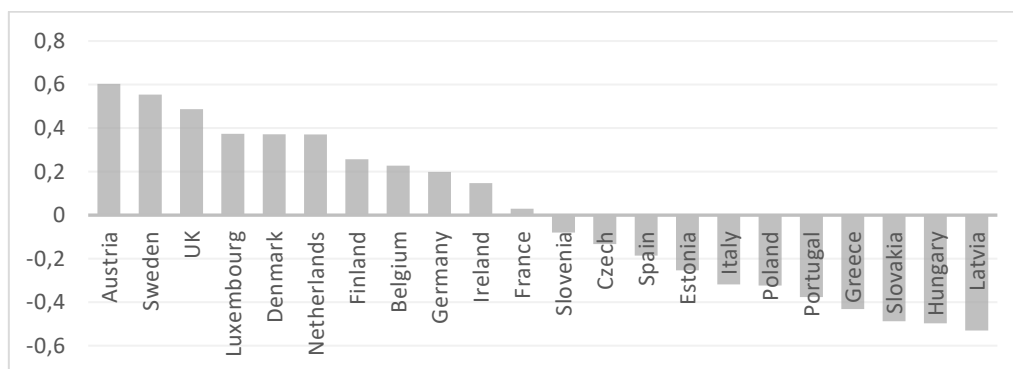
In the first step, 27 socioeconomic indicators were grouped into 10 categories, and the value of each of the category is determined using the SAW method and equal weighting for indicators within each of the category. In the next step, category weights were determined using the standard deviation method (Table 2). The results indicate that the housing, income and labour market category have the greatest impact on the quality of life.

Table 2 Weights of quality of life categories

Category	Life satisfaction	Housing	Income	Labour market	Education
Weights	0.096397	0.104601	0.120834	0.105443	0.097716
Category	Environment	Civic engagement, governance and basic rights	Health	Economic security and physical safety	Work-Life Balance
Weights	0.099079	0.098689	0.096134	0.085757	0.09535

In the third step, PROMETHEE method was applied to assess the quality of life of selected European countries and the results indicate that most of the countries of Northern and Western Europe achieve the highest quality of life for their residents (Figure 1).

Figure 1. Value of net outranking flows for the evaluated countries



In the fourth step, the correlation analysis was performed to determine the relationship between the assessed quality of life and the crude net migration rate. The value of the Spearman's correlation coefficient (0.560) indicates that there is a significant, moderately strong positive relationship between quality of life and migrations.

CONCLUSIONS

The earlier understanding that migrations are primarily conditioned by better economic conditions is abandoned, and several other socio-economic and environmental factors are taken into consideration in the studies. Although it is common to measure material living standards of a country through gross domestic product, such a measure often fails to cover other important dimensions of quality of life, such as quality of education, personal health, quality of the labour market, and life satisfaction in general. Migrants expect that their well-being, based on economic and non-economic factors, will be higher in the new region compared to their previous place of residence (Faggian et al., 2012).

The paper aimed to examine the relationship of quality of life in selected European countries and migrations, and the results indicate that there is a positive relation, signifying that higher quality of life in the particular country indicates the greater desirability of that country as the final destination of the migratory movement of the population.

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Session 23: Optimization

chair: Yannis Marinakis

Link Prediction in Signed Social Networks: The Case of Bitcoin Users

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Abstract

During the last decade, social networks appear in many aspects of modern life. By their nature, these networks are dynamic objects and, thus, questions have been emerged regarding their evolvement during time. The availability of large datasets encoding network information along with the novel machine learning algorithms/solutions have made possible the extensive study of social network properties and structural features. In our work, we study the well-studied link prediction problem which seeks to accurately predict future possible links on the network or missing links due to incomplete data. The most common modelling approach is to represent these networks as graphs, where the nodes represent entities while the edges/links represent the association between entities. We focus on weighted signed social networks and try to predict new edges in a real-world dataset. Specifically, a Bitcoin network is being employed where different users rate the level of trust (on a scale ranging from -10 to 10, excluding 0) they have in other users. Three different frameworks for representation learning on large graphs have been used; namely, Node2Vec, CDTNE and GraphSage. Following, standard steps involved in supervised learning, the performance of the selected learning functions have been measured using well-known metrics (e.g. accuracy, precision, AUC-score) for each implementation strategy employed in our analysis. All three employed techniques are compared under the aforementioned Bitcoin-related network and the results provide distinct useful insights on the network's future formation. Additionally, the same methodologies are applied to a well-known dataset citation network of scientific publications (known as CORA dataset) in order to validate further the conclusions of the preceding analysis. Finally, we discuss how the different methodologies regarding network embeddings and link prediction frameworks can be combined effectively to achieve better results regarding the link prediction problem.

KEYWORDS

Signed networks, Link prediction, Node2Vec, GraphSAGE, CDTNE

INTRODUCTION

Considerable attention has been devoted to the computational analysis of complex networks in the last few years. Especially in the context of social networks, modelled using graph-theoretical concepts, nodes represent people or other entities in the social content, while edges usually represent aspects such as friendship, collaboration, influence etc. among the aforementioned entities. Social networks are highly dynamic objects and the identification of their future status and/or their evolvement over time is of great importance in today's networking environment (Barabasi (2016)).

Complex networks have application in many areas of science and aspects of modern life. Among the many and interesting problems in the area of complex networks we shall focus on the so-called link prediction problem. This problem concerns the prediction of future links in a network or the inference of missing links due to absence of specific data. In other words, the basic idea of link prediction is to approximate the possibility of the existence of a link between a pair of nodes, where the only available information is the topological structure of the network. There are numerous applications which can benefit by solving efficiently particular versions of the link prediction problem. A classic example is associated with the recommendations/suggestion options of new followers/friends on social network platforms (e.g. Facebook, LinkedIn, Twitter). Another one concerns the suggestion of interests/activities that seem to be collective (e.g. recommendation of products on Amazon, suggestion of movies on Netflix) (Ahmad et al (2020)).

The evolvement of a network is highly dependent on its type (e.g. academic, financial) and, thus, different link prediction algorithms and associated implementations may produce different results. This implies that an approach may work much better on a network of specific type. In this work, we apply supervised learning techniques utilizing three known platforms that can handle graph-type data. Our main interest is to examine and predict the evolvement of new types of financial networks and, specifically, those formed by the traders of cryptocurrencies. Based on a publicly available

dataset concerning the trust level among Bitcoin users, we predict with three different implementations the future state of the aforementioned network. Finally, we examine the performance of all three implementations in a well-studied dataset and show that the performance of the three approaches are highly dependent on the setting of the problem.

DATASETS

In order to perform our analysis two datasets have been used. The first concerns the level of trust between users of a Bitcoin trading platform. There is anonymity between users which may lead to distinct types of risk, such as counterparty risk. Therefore, the formation of a network where the nodes represent users and edges represent existing exchanges between users seems to be the correct tool to model that community and reduce the counterparty risk. Furthermore, a weight is attached to each edge in order to express the level of trust ranging from -10 to 10, excluding 0, where -10 is given to “fraudsters” while 10 is given to people that “you trust more than yourself” (the dataset is available in www.bitcoin-otc.com). For the purpose of our experiments the aforementioned ratings have been regularized to belong to the $[0,1]$ range. The final network consists of 5881 nodes and 35592 edges. In order to validate further the results of our implementation a well-studied dataset has also been employed. Specifically, the so-called CORA citation network has been used which consists of 2708 scientific publications (nodes) and 5429 citations (edges) (the dataset is available in <https://relational.fit.cvut.cz/dataset/CORA>; original source: linqs.cs.umd.edu).

METHODOLOGY AND IMPLEMENTATION

In order to conduct our experiments, three different frameworks were utilized for each dataset and the whole set of experiments was designed in a way that the obtained results could be used for comparison purposes among the three implementations. Specifically, the frameworks used are: Node2Vec, CTDNE (Continuous-Time Dynamic Network Embeddings) and GraphSage (see Grover and Leskovec (2016), Nguyen et al. (2018) and Hamilton et.al. (2017), respectively). The description of the three approaches and the details regarding their implementations for the problem under consideration are provided in the following subsections.

Node2Vec implementation:

Regarding the Node2Vec implementation, the Stellargraph framework (CSIRO's Data61 (2018)) has been employed in order to handle effectively the graph objects. It should be noted that edge weights were used when available from the given dataset. Given an initial graph, say G , we have first removed the 10% of the edges in order to obtain the test graph G_{test} . This graph was then used in the process of learning node embeddings and for conducting the performance tests during the validation phase. The removed *positive edges* (actual edges) are accumulated in a list along with an equal number of *negative edges* (non-existent edges); furthermore, a list with a binary variable is created to indicate whether or not an edge is positive (these two lists are used in order to validate the implemented models at the end of the process).

In order to obtain the training graph, which is used to learn node embeddings during the training of the models, 10% of the edges were removed from the graph G_{test} . Also, the removed edges and an equal number of randomly created *negative edges* have been collected to form an edge-list. That list was split in a 75/25 ratio, where the first slice is used to train the classifiers while the second slice is used in order to select the best operator for the creation of edge embeddings from node embeddings.

During the training of the models, we first apply the process of learning the node embeddings. To do so, random walks are performed on the graph and these walks are then fed to a *Word2Vec* model (Mikolov et al. (2013)) in order to acquire the node embeddings. At this point, an execution regarding the search for the best edge embedding operator takes place. For each available operator, (e.g. Hadamard, Average, Weighted-L1, Weighted-L2) we train a logistic regression with cross validation classifier. Each classifier is then validated using the Accuracy, F1 score and AUC score metrics. The best operator is selected using the AUC score metric.

The model is then validated on the testing data using the parameters specified in the training stage. Node embeddings are learned on the test graph, and the edge embeddings are then extracted using the best operator from the previous stage. The final performance of the model is measured on the testing data using the three metrics mentioned above.

CTDNE implementation:

The CTDNE implementation used for the purposes of our work is based heavily on the Node2Vec implementation; however, it was necessary to apply a modification in order to fit our problem setting to this particular framework. Specifically, the timestamps regarding the creation of the edges (whenever available, such as in the OTC Bitcoin case) are used as edge weights. It should also be noted that, during the node embedding learning, temporal walks are fed to the Word2Vec model. All other implementation aspects, such as the data split and the preprocessing steps, are exactly the same as in the Node2Vec implementation.

GraphSAGE implementation:

The data preprocessing and split steps are exactly the same as in the Node2Vec implementation. Although, the GraphSAGE framework requires node features in order to work, these features are artificially constructed using the node embeddings learned through Node2Vec. For the purposes of our analysis a two-layer GraphSAGE model has been developed; namely, the first layer is used to learn node representations, while the second one is a link classification layer. Finally, the two layers are combined in a final Keras model (Chollet et al. (2015)).

RESULTS AND CONCLUSIONS

The results regarding the experiments on the OTC Bitcoin dataset and the CORA dataset, using the implementations described in the preceding section, are given in Tables 1 and 2, respectively.

Table 1: Results on the OTC Bitcoin Dataset

<u>Implementation</u>	<u>Accuracy</u>	<u>AUC</u>	<u>F1 Score</u>	<u>Precision</u>	<u>Recall</u>
Node2Vec	0.6024	0.5840	0.7120	0.6629	0.6416
CTDNE	0.8350	0.8475	0.8171	0.8973	0.8320
GraphSAGE	0.7527	0.5008	0.4669	0.8817	0.4827

Table 2: Results on the CORA Dataset

<u>Implementation</u>	<u>Accuracy</u>	<u>AUC</u>	<u>F1 Score</u>	<u>Precision</u>	<u>Recall</u>
Node2Vec	0.8235	0.8350	0.8065	0.8814	0.8204
CTDNE	0.7419	0.7457	0.7343	0.8416	0.7400
GraphSAGE	0.7837	0.5016	0.4425	0.8698	0.4671

As it can be observed, in the OTC Bitcoin case, the CTDNE framework seems to outperform the other two implementations, which is expected since that framework was designed especially for temporal data. Meanwhile, Node2Vec demonstrates good results in the CORA dataset case, which as mentioned before, represent a more “traditional” type of problem. GraphSAGE is an overall good-performing solution, that performs relatively consistently across the different types of data, being generally closer to the best performing framework rather than the worst performing one. As a final remark, the combination of the GraphSAGE with the Node2Vec seems to present a very efficient and versatile solution that produces good results in a plethora of problems. Although Node2Vec simply transforms the data, which in our case are the node representations, without providing any new information, treating these transformations as node attributes has shown promising results in both cases presented in this paper.

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Honey Bees Mating Optimization Algorithm for the Berth Allocation Problem

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Abstract

The growing demand of maritime logistics is developed from the research of maritime transportation within the context of supply chain management. The connection between supply chain integration and shipping firm performance reflects on the quality of the maritime logistics services. Therefore, complete maritime logistics systems involve a series of crucial operations: port management activities, shipping strategies and freight forwarding planning. Particularly, in maritime transportation, an effective and organized plan for ship arrivals is necessary prerequisite for the success of the entire port logistics. Handling a specific amount of ships depends on their arrival time, their handling or working time in the port and the availability of the current berth to service them. This specific set of acts is denoted as Berth Allocation Problem (BAP). The aim of the BAP is the allocation of berths for a set of vessels scheduled to arrive at the port within the planning horizon in order to minimize the sum of their waiting and handling time at the port. BAP is a NP-hard problem according to its complexity and it presents quite few similarities with the mathematical model of Multi Depot Vehicle Routing Problem with Time Windows (MDVRPTW). To tackle effectively BAP, we developed an innovative optimization method based on the nature inspired algorithms, which follows the behavior of bees. To solve BAP, we select the Honey bees mating (HBMO) optimization algorithm due to its adaptiveness in numerous optimization problems. HBMO belongs to the category of evolutionary algorithms and their applications can be found in both continuous and discrete optimization fields. We compared the proposed algorithm with other algorithms from the literature and the computational results proved the efficiency of the method for the studied problem.

KEYWORDS

Honey Bees Mating Optimization Algorithm, Berth Allocation Problem, Maritime Transportation.

INTRODUCTION

During the last years an increasing interest on all aspects of maritime logistics has been performed by researchers in the field. One of the most important problems in the field of maritime logistics is the berth allocation problem as an effective and organized plan for ship arrivals and handling at the port is necessary prerequisite for the success of the entire maritime logistics. In this paper, the berth allocation problem (BAP) is studied and solved using an approach based on a nature inspired algorithm, the Honey Bees Mating Optimization (HBMO) algorithm. The aim of BAP is the allocation of berth space for vessels that arrive over time in container terminals in order to be served, loading and unloading containers, as soon as possible. It should be noted that different factors affect the berth and time assignment of each vessel. As it has, already, been mentioned in order to solve effectively BAP, we developed an optimization method based on the Honey Bees Mating Optimization algorithm (HBMO). HBMO is the most known algorithm based on the marriage behaviour of the bees and simulates the mating process of the queen of the hive. The mating process of the queen begins when the queen flights away from the nest performing the mating flight during which the drones follow the queen and mate with her in the air. The proposed algorithm adopts the basic characteristics of the initially proposed Honey Bees Mating Optimization algorithm and, also, makes a combined use of a number of different procedures in each of the subphases of the main algorithm in order to increase the efficiency of the proposed algorithm. The rest of the paper is organized as follows: a brief literature review concerning BAP in addition to the mathematical formulation of BAP are presented in Section 2. The proposed methodology HBMO, inspired from the behavior of the bees and developed to match the restrictions of BAP, is introduced in Section 3. The computational results obtained from the algorithmic procedure are summarized in Section 4 while in the final section conclusions are presented.

BERTH ALLOCATION PROBLEM (BAP)

Essential seaport operations are carried out in port terminals which affect the international trade market and transportation. One of the basic port operations is the planning of predefined set of ships with specific berth assignments according to a tight timetable or a limited time horizon. The strategical planning of ships berthing in ports is denoted as the Berth Allocation Problem (BAP). BAP is categorized as a NP-hard problem due to its computational complexity. The objective is the minimization of the total (weighted) service time for all ships, defined as the time elapsed between the arrival in the harbor and the completion of handling. Two versions of the BAP are considered: the discrete case and the continuous case. The discrete case works with a finite set of berthing points while in the continuous case ships can berth anywhere along the quay. According to the assignments of the ships at the port, BAP can be categorized into two separate approaches as the dynamic BAP (DBAP) or static BAP (SBAP). In the static version of the problem, all vessels arrive at the terminal before the starting planning time, while the dynamic version takes into account the vessels that arrive at any time of the planning horizon. In this paper, we study the discrete dynamic berth allocation problem. In the literature, various mathematical formulations can be found for this problem (Cordeau et al. (2005), Imai et al. (2001)).

In this study, we formulated the BAP as a heterogeneous vehicle routing problem with time windows (HVRPTW) where berths correspond to vehicles, ships correspond to customers and a mooring sequence at a particular berth corresponds to a vehicle route. Each vehicle must start and end at the depot. The depot is divided into two dummy nodes, o and d . Time windows can be imposed on every node. The time windows of a vehicle correspond to the availability time of the corresponding berth. (Buhrkal et al. (2011), Ting (2014)). HVRPTW is defined on a graph $G = (V, A)$, where in $V = N \cup \{o, d\}$ all ships with the origin and the destination nodes of the graph are included. Each ship $i \in N$ is linked with a time window $[\alpha_i, b_i]$, which indicates the arrival and the departure time of the current ship, a service priority v_i and a handling time h_i^k . For the origin and destination vertices, the time window $[s^k, e^k]$ depends on the berth (vehicle) k as berths can be available at different times. The decision variables are divided into binary decision variables ($x_{ij}^k, \in M, (i, j) \in A$) and continuous variables ($T_i^k, i \in V, k \in M$). If ship j immediately follows up ship i , then x_{ij}^k is equal to 1, otherwise is equal to 0. T_i^k denotes the time for ship i to moor at berth k , or takes value a_i if berth k is unused. T_o^k and T_d^k show the start and the finish time of activities at berths $k \in M$.

$$\min \sum_{i \in N} \sum_{k \in M} v_i \left(T_i^k - a_i + h_i^k \sum_{j \in N \cup \{d\}} x_{ij}^k \right) \quad (1)$$

s.t.

$$\sum_{k \in M} \sum_{j \in N \cup \{d\}} x_{ij}^k = 1 \quad \forall i \in N \quad (2)$$

$$\sum_{j \in N \cup \{d\}} x_{oj}^k = 1 \quad \forall k \in M \quad (3)$$

$$\sum_{i \in N \cup \{o\}} x_{i,d}^k = 1 \quad \forall k \in M \quad (4)$$

$$\sum_{j \in N \cup \{d\}} x_{ij}^k = \sum_{j \in N \cup \{o\}} x_{ji}^k \quad \forall k \in M, i \in N \quad (5)$$

$$T_i^k + h_i^k - T_j^k \leq (1 - x_{ij}^k) M_{ij}^k \quad \forall k \in M, (i, j) \in A \quad (6)$$

$$a_i \leq T_i^k \quad \forall k \in M, i \in N \quad (7)$$

$$T_i^k + h_i^k \sum_{j \in N \cup \{d\}} x_{ij}^k \leq b_i \quad \forall k \in M, i \in N \quad (8)$$

$$s^k \leq T_o^k \quad \forall k \in M \quad (9)$$

$$T_d^k \leq e^k \quad \forall k \in M \quad (10)$$

$$x_{ij}^k \in \{0, 1\} \quad \forall k \in M, (i, j) \in A \quad (11)$$

$$T_i^k \in \mathbb{R}^+ \quad \forall k \in M, i \in V \quad (12)$$

The objective function (1) minimizes the total cost summarizing the waiting times and the processing times of the ships. Constraint (2) ensures that each ship must be assigned to exactly one berth k . Constraints (3) and (4) enforce for each

berth k that the origin destination nodes is one. Flow conservation for the remaining vertices is guaranteed by constraint (5). Constraint (6) notes the consistency for berthing time and mooring sequence on each berth. Constraints (7) and (8) ensure the time windows limits for each ship. The berth availability is enforced by constraints (9) and (10). Last but not least, constraints (11) and (12) define the respective domains of the decision variables.

HONEY BEES MATING OPTIMIZATION ALGORITHM

The Honey Bees Mating Optimization (HBMO) algorithm was introduced by Abbass et al. (2001) and it was inspired from the mating behavior of the honey bees in the nature and, more precisely, from the mating behavior of a queen bee in a hive. The HBMO algorithm is one of the most suitable swarm intelligence algorithms for the solution of routing problems as it was proved in Marinakis et al. (2008) for the solution of the Capacitated Vehicle Routing Problem and, then, it was applied with the suitable modifications for the solution of a number of other routing problems. This is the reason why in this paper we selected to propose a variant of the Honey Bees Mating Optimization algorithm for the solution of the Berth Allocation Problem as we chose the formulation of the problem that is based on the Vehicle Routing Problem.

The proposed HBMO algorithm for the solution of the discrete dynamic BAP consists of 6 phases:

- Phase 1: Set termination criteria, initialize the population and find the queen (best solution of the initial population).
- Phase 2: Mating procedure to form spermatheca. The mating is performed between the queen and some of the drones based on a number of conditions same as the ones proposed in the modified HBMO algorithm (Marinakis et al. (2008))
- Phase 3: Creation of new broods using a multiparent crossover operator by combining queen's genotype with randomly selected drones' genotype. The drones are selected from spermatheca.
- Phase 4: Application of workers for broods' improvement (local search procedures).
- Phase 5: Update the queen if the most profitable brood performs better than the queen bee.
- Phase 6: Completion of termination criteria.

HBMO algorithm starts with the initialization of the population of bees, where the best member of the population becomes the initial queen while the other members of the population are the drones. The initial population is created using Greedy Randomized Adaptive Search Procedure (GRASP). Afterwards the spermatheca is created using the equations of energy and speed as they are proposed by Marinakis et al. (2008). In spermatheca the most suitable drones are stored. In Phase 3, a multiparent crossover is used to generate the population of broods by mixing parts of the solution of the queen bee and parts of the solution of randomly selected drones from the spermatheca. In phase 4, a local search procedure is applied in each brood separately. The local search algorithms that are used in this research are the 1-0 relocate, the 1-1 exchange and the 2-opt. If a solution of a brood performs better than the solution of the queen bee, then, the brood becomes the new queen bee and the procedure is repeated. The new set of drones is formed by selecting the best solutions from the old queen (if it was replaced by a brood), from the current drones and from the broods, taking into account that the population number is the same in each iteration. The algorithm terminates when the number of predefined iterations is reached.

COMPUTATIONAL RESULTS FOR BAP

The performance of our proposed HBMO algorithm is tested in the benchmark instances from the literature. The computational results are presented through Tables 1-3 and the instances are divided according to the fleet of vessels and the total berths. Tables 1-3, are organized in five columns. The first and the second columns denote the features and the instance number of each set, respectively. In third and fourth columns the best-known solutions (BKS) (Lalla-Ruiz et al. (2012)) and the obtained results from the HBMO method are presented. In the last column the relative deviation (RD) of HBMO's results from the BKS is given. In Table 1, HBMO reaches the BKS in the majority of the instances. In the medium set of instances (Table 2), the obtained results, which reach the BKS, are less than in the previous set of instances, while the largest deviation from the BKS is found in instances 55x07-10 and 55x10-8 with 0.8%. In the last set of instances with the highest complexity (Table 3), the proposed algorithm achieves very good results with average RD equal to 0.1% in 60x05 set of instances and equal to 0.3% in 60x07, respectively. In summary, in total of 90 instances the proposed algorithm finds in all instances solutions with deviation from the BKS less than 1% and the BKS is found in 21 instance while in total the average relative deviation is equal to 0.24%.

Table1. Small set of instances					Table2. Medium set of instances					
Fleet x	No	BKS	HBMO	RD	Fleet x	Berths	No	BKS	HBMO	RD
Berths										
30 x 03	1	1763	1763	0%	40 x 07		1	1460	1471	+0.7%
30 x 03	2	2090	2090	0%	40 x 07		2	1375	1378	+0.2%
30 x 03	3	2186	2186	0%	40 x 07		3	2119	2133	+0.6%
30 x 03	4	1538	1538	0%	40 x 07		4	1597	1602	+0.3%
30 x 03	5	2114	2114	0%	40 x 07		5	1847	1863	+0.8%
30 x 03	6	2185	2185	0%	40 x 07		6	2080	2088	+0.3%
30 x 03	7	1845	1847	+0.1%	40 x 07		7	1841	1841	0%
30 x 03	8	1271	1271	0%	40 x 07		8	2026	2026	0%
30 x 03	9	1595	1595	0%	40 x 07		9	1880	1890	+0.5%
30 x 03	10	2195	2195	0%	40 x 07		10	1892	1905	+0.6%
30 x 05	1	1149	1150	+0.08%	55 x 05		1	4689	4705	+0.3%
30 x 05	2	1475	1476	0%	55 x 05		2	5467	5476	+0.1%
30 x 05	3	1542	1544	+0.1%	55 x 05		3	5499	5501	+0.03%
30 x 05	4	1075	1075	0%	55 x 05		4	4179	4192	+0.3%
30 x 05	5	1463	1463	0%	55 x 05		5	5478	5496	+0.3%
30 x 05	6	1580	1580	0%	55 x 05		6	5595	5603	+0.1%
30 x 05	7	1276	1276	0%	55 x 05		7	4882	4886	+0.1%
30 x 05	8	870	870	0%	55 x 05		8	3552	3567	+0.4%
30 x 05	9	1134	1134	0%	55 x 05		9	4275	4289	+0.3%
30 x 05	10	1527	1528	+0.06%	55 x 05		10	5739	5753	+0.2%
40 x 05	1	2301	2301	0%	55 x 07		1	2846	2871	+0.8%
40 x 05	2	2829	2838	+0.3%	55 x 07		2	2883	2899	+0.5%
40 x 05	3	2880	2881	+0.03%	55 x 07		3	3833	3855	+0.5%
40 x 05	4	2001	2004	+0.1%	55 x 07		4	2971	2978	+0.2%
40 x 05	5	2815	2825	+0.3%	55 x 07		5	3801	3825	+0.1%
40 x 05	6	2934	2943	+0.3%	55 x 07		6	3783	3795	+0.3%
40 x 05	7	2632	2640	+0.3%	55 x 07		7	3774	3783	+0.2%
40 x 05	8	1835	1836	+0.4%	55 x 07		8	3863	3876	+0.3%
40 x 05	9	2086	2098	+0.5%	55 x 07		9	3591	3609	+0.5%
40 x 05	10	2962	2962	0%	55 x 07		10	3635	3665	+0.8%
					55 x 10		1	2745	2754	+0.3%
					55 x 10		2	2534	2546	+0.4%
					55 x 10		3	2545	2556	+0.4%
					55 x 10		4	3315	3325	+0.3%
					55 x 10		5	3123	3142	+0.6%
					55 x 10		6	2283	2289	+0.2%
					55 x 10		7	2146	2146	0%
					55 x 10		8	2726	2749	+0.8%
					55 x 10		9	2162	2170	+0.3%
					55 x 10		10	2815	2833	+0.6%

Table 3. Large set of instances

Fleet x Berths	Instances	BKS	HBMO	RD
60 x 05	1	5753	5763	+0.1%
60 x 05	2	6884	6897	+0.1%
60 x 05	3	6780	6791	+0.1%
60 x 05	4	5105	5118	+0.2%
60 x 05	5	6715	6731	+0.2%
60 x 05	6	6616	6624	+0.1%
60 x 05	7	6011	6017	+0.01%
60 x 05	8	4385	4397	+0.1%
60 x 05	9	5235	5245	+0.1%
60 x 05	10	7281	7291	+0.1%
60 x 07	1	3715	3732	+0.4%
60 x 07	2	4172	4185	+0.3%
60 x 07	3	4281	4302	+0.4%
60 x 07	4	3916	3934	+0.4%
60 x 07	5	4261	4290	+0.7%
60 x 07	6	5729	5739	+0.1%
60 x 07	7	3743	3759	+0.4%
60 x 07	8	4586	4606	+0.4%
60 x 07	9	4004	4006	+0.04%
60 x 07	10	4115	4128	+0.3%

CONCLUSIONS

In this paper, a new Honey Bees Mating Optimization algorithm is presented for solving the Discrete Dynamic Berth Allocation Problem. The proposed methodology proved effective enough to withstand against efficient methods from the literature. Our future research will be concentrated into three directions. Initially, further enhancements of HBMO will be developed to increase its performance, while its impact will be examined in more complex and larger set of instances for BAP. Secondly, the development of various and efficient metaheuristic algorithms is in our primary interests. Finally, the fundamental aim of our scientific work focuses on the expansion in other optimization areas and problems, while BAP can be connected and combined with various maritime problems such as quay crane scheduling.

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Profit Optimization in a Two-Parking Lots System with Priority Clients using Resource Reservation Policies

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Abstract

A two-parking lot system is considered which is near an airport terminal and can be accessed by clients who intend to travel. The clients arrive at the first parking lot (P1) where they can have access unless it is full. In this case, the clients are sent to the second parking lot (P2), where they can park if there are free places. Given that the parking lots are owned by the same company, its intention is to increase the profit by providing service to as many clients as possible. However, the parking lots can be accessed by clients with different demands. Thus, we propose a model, based on a continuous time Markov chain (CTMC), in which clients are partitioned into priority classes with different privileges and ticket prices. The highest priority classes can have access to all parking places, though lower priority classes can access fewer. To achieve this, parking places are reserved in both lots for higher priority classes. The aim is to increase the total profit, and simultaneously minimize the blocking probability for all classes. Thus, a multi-objective optimization problem is formulated, the solution of which provides the optimal number of reserved parking places for each class. A numerical example is finally provided to illustrate the theoretical framework.

KEYWORDS

resource reservation; priority classes; Markov chain; blocking probabilities; multi-objective optimization.

INTRODUCTION

Resource availability optimization is of critical importance when dealing with client-server systems. During the past years, a lot of research attention has been paid on optimizing resource availability (Koutras & Platis (2006), Xiao et al. (2004), Salagaras et al. (2017), Salagaras et al. (2016)). Usually, resource availability optimization is assured by adopting the concept of resource reservation. In detail, clients are partitioned into priority classes and resources are reserved for the higher priority classes. This is the case in (Koutras & Platis (2006)), where website resources are reserved for higher priority clients, though in (Salagaras et al. (2016)) resource availability optimization through resource reservation is studied for a point-to-point connection on a telecommunication network. Similarly, the concept of resource reservation is adopted in (Salagaras et al. (2017)), where a parking lot providing its clients with parking places is considered. Clients are partitioned into priority classes according to different parking places reservation options (monthly parking, hourly parking, parking on demand, etc). In these approaches, the aim is to distinguish a trade-off between providing service to as many clients as possible and simultaneously provide higher levels of resource availability to higher priority classes. To achieve this trade-off, the probability that a client of certain class cannot have further access to system resources, called blocking probability (Farago (2000), Ioannou et al. (2002), Trivedi et al. (2002)), is considered and a multi-objective optimization (MOO) problem is then solved, based on these probabilities. The solution of the MOO problems provides the optimal resource reservation policy that manages to simultaneously minimize the blocking probability for all clients' classes.

In this paper, resource availability optimization under optimal resource reservation policies is considered for a two-parking lot system (P1 and P2), assumed to be placed nearby an airport terminal, owned and managed by a company, and can be accessed by clients of different needs who usually intend to travel. We propose an approach in which all arrivals follow Poisson process and moreover, each client stays at the parking lot for an exponentially distributed time. Thus, we use a CTMC to model the number of free parking places and we propose to partition clients into different priority classes with different privileges and ticket prices. Higher priority classes pay a more expensive ticket to enter the parking-lots (either P1 or P2), but they achieve lower blocking probability. Managing company's aim is to accept as many clients as possible, increasing hence the total profit, and simultaneously minimize all classes' blocking probabilities. To achieve this, a MOO problem is proposed, the solution of which provides the optimal number of reserved parking places for each priority class that maximizes the total daily profit and simultaneously minimizes classes' blocking probabilities.

RESOURCE RESERVATION AND OPTIMIZATION IN TWO-PARKING LOTS SYSTEM

Let us assume that visiting clients are partitioned into k priority classes. Let Class 1 be the class with the highest priority among all the others. Let also Class i , $i = 2, \dots, k$ be the class of clients that has higher priority than Class j for $j > i$, but lower priority than Class l , for $l < i$. Priorities among clients' classes refer to the access that a client has on the parking places in P1 and P2 and the corresponding blocking probability. Thus, the highest priority Class 1 must be provided with the lower blocking probability though Class 2 should achieve a blocking probability lower than Classes 3, ..., k and so on. Due to these ascending order privileges offered to the clients, Class i should pay a ticket for entering P1 or P2 of c_i cost units (c.u.) per day, which is higher than c_j for $j > i$, but lower than c_l for $l < i$. Thus, for the k classes, $c_k < c_{k-1} < \dots < c_2 < c_1$.

To provide higher priority classes with more parking places, we propose a parking places' reservation policy for each parking lot, which will be in accordance with classes' priorities. In detail, we propose to reserve a number of parking places which can be used only from higher priority classes. Thus, let $\mathbf{g}^l = (g_1^l, g_2^l, \dots, g_{k-1}^l)$ for $l = \{P1, P2\}$, be the reserved parking places in parking lot l ; g_{k-1}^l represents the parking places in parking lot l that are reserved for the highest priority Class 1, while g_{k-2}^l represents the parking places in parking lot l that can be accessed by Class 1 and Class 2 and so on, until g_1^l which represents the parking places in parking lot $l = \{P1, P2\}$ that can be accessed by all classes except Class k . Thus, if parking lot l has N places in total, then Class 1 can have access to all parking places, while Class k can have access to $N - \sum_{i=1, \dots, k-1} g_i^l$ places.

For modeling the two-parking lot system and computing the blocking probabilities and the daily profit, we are interested in the free parking places in P1 and P2. Assuming that the arrival process for Class i can be modelled by a Poisson process of parameter $\lambda_{class\ i}$ and that the time that a vehicle remains at the parking lots (P1 or P2) independently of the class, is exponentially distributed with parameter μ , a continuous time Markov chain $\{X(t), t \geq 0\}$ (CTMC) is used to model the free parking places at the parking-lots system at time t . The state space of $X(t)$ consists of pairs (i, j) , with i denoting the number of free parking places in P1 and j the free parking places in P2 respectively. So, if we assume that P1 consists of N_1 parking places in total, and P2 consists of N_2 parking places in total, the state space is $E = \{(i, j), i \in \{0, \dots, N_1\}, j \in \{0, \dots, N_2\}\}$.

Initially both parking lots are empty, that is P1 can provide N_1 and P2 can provide N_2 places. In this case, all clients arrive at P1 with rate $\lambda_1 = \sum_{i=1}^k \lambda_{class\ i}$. This is the case until the free parking places in P1 reduce to $\sum_{i=1}^{k-1} g_i^{P1}$. In this case the lower priority Class k is blocked from P1 due to the fact that the remaining parking places in P1 are reserved for the higher priority Classes 1, ..., $k-1$. Thus, Class k is sent to P2 where access is allowed until the free parking places reduce to $\sum_{i=1}^{k-1} g_i^{P2}$. Then, while the free places in P1 are $\sum_{i=1}^{k-1} g_i^{P1}$ clients of Class 1 to Class $(k-1)$ continue to access P1 with arrival rate $\lambda_2 = \sum_{i=1}^{k-1} \lambda_{class\ i}$. This is the case until the free parking places in P1 reduce to $\sum_{i=2}^{k-1} g_i^{P1}$. In this case, Class $(k-1)$ is blocked from P1 and is sent to P2 where access is allowed until the free parking places reduce to $\sum_{i=2}^{k-1} g_i^{P2}$. The arrival process as well as the blocking process continues until there are g_{k-1}^{P1} free places in P1, that can be accessed only by clients of Class 1 whose arrival rate is $\lambda_k = \lambda_{class\ 1}$. Thus, Class 2 is blocked from P1 and sent to P2 until the free parking places reduce to g_{k-1}^{P2} . Finally, when there is no free parking place left in P1, clients of Class 1 are blocked from P1 and sent to P2 until there is no free parking place in P2 too. As far as the service rate, it is assumed that a client of any class is served when leaving the parking-lots area (either P1 or P2) after an exponentially distributed time with mean $1/\mu$. Figure 1 illustrates a certain problem instance.

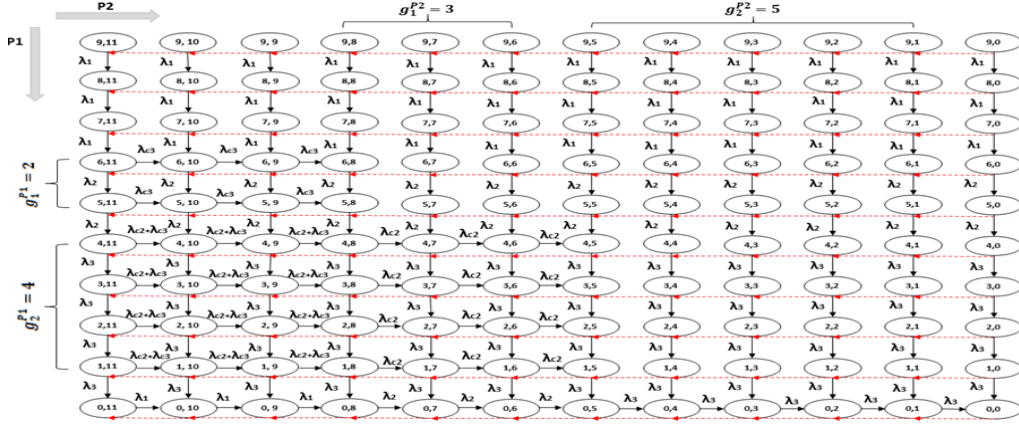
We are interested in computing the asymptotic probability that a certain class of clients is blocked in P1 or in P2, using the steady state probability distribution $\boldsymbol{\pi}$ of the related Markov process which is computed by solving the system $\boldsymbol{\pi} \cdot \mathbf{Q} = \mathbf{0}$, $\sum_{(i,j) \in E} \pi_{i,j} = 1$, where \mathbf{Q} is the kernel matrix, and E is the state space. Actually, we are interested in the blocking probability of any class in P2. Based on the reservation policy, the arrival and service process and the transitions among system states, the blocking probability for Class 1 is:

$$P_{b,class\ 1} \equiv P_{b,Class\ 1}^{P2} = \pi_{0,0} \quad (1)$$

Correspondingly, the blocking probability for Class l , $l \in \{2, 3, \dots, k\}$ in P2 is computed as follows:

$$P_{b,class\ l} \equiv P_{b,Class\ l}^{P2} = \sum_{i=0}^{\sum_{m=k-(l-1)}^{k-1} g_m^1} \sum_{j=0}^{\sum_{m=k-(l-1)}^{k-1} g_m^2} \pi_{i,j} \quad (2)$$

Figure 1. State transition diagram for a problem instance with $N_1 = 8$, $N_2 = 12$, and $k = 3$ priority classes ($\rightarrow \mu$)



The aim of the company is to determine the optimal parking places reservation policy that maximizes the total expected daily profit. To achieve this goal, the company needs to provide access to as many clients as possible with respect to the order of priorities. This goal is attained by solving a MOO problem. Prior to this, the total expected daily profit can be computed by the following formula:

$$TEDP = \sum_{i \in \{1,2,\dots,k\}} \lambda_{Class i} \cdot (1 - P_{b,Class i}) \cdot c_i \quad (3)$$

Interpreting Eq. (3), a client of Class i who arrives at the parking-lots area and finds a free parking place in P1 or in P2 with probability $1 - P_{b,Class i}$, pays a ticket of price c_i , for $i \in \{1,2, \dots, k\}$.

Given that the aim is to maximize the expected daily profit earned by the tickets paid by clients entering either P1 or P2, an optimization problem with the objective to maximize $TEDP$ of Eq. (3) needs to be solved. However, the daily profit strongly depends on the number of clients that manage to enter the parking-lots area. Thus, $TEDP$ is not the only objective of this problem. To assure that as many clients as possible can have access to the parking-lots area for increasing company's profit, the blocking probability for each class needs to be minimized. Consequently, an optimization problem with multiple objectives needs to be solved. A classical approach to do so, is to choose one of these objective as the primary one, and include the rest as constraints bounded by an upper level $P_{b,Class i}^0$, $i \in \{1,2, \dots, k\}$ which is chosen by the managing company and assures that each class achieves a blocking probability lower than this. Hence, the MOO problem to be solved, is as follows:

$$\begin{aligned} & \max TEDP (g_1^1, \dots, g_{k-1}^1, g_1^2, \dots, g_{k-1}^2) \\ & \text{s. t. } P_{b,Class i} \leq P_{b,Class i}^0, i \in \{1,2, \dots, k\} \\ & \sum_{i=1}^{k-1} g_i^1 < N_1 - 1, \sum_{i=1}^{k-1} g_i^2 < N_2 - 1, \sum_{i=1}^{k-1} g_i^1 < N_1 - 1, \sum_{i=1}^{k-1} g_i^2 < N_2 - 1 \\ & g_i^1 < g_{i+1}^1, g_i^2 < g_{i+1}^2, g_i^1 > 1, g_i^2 > 1, i, g_i^1, g_i^2 \in \mathbb{Z}^+, i \in \{1,2, \dots, k-1\} \end{aligned} \quad (4)$$

Constraints $g_i^1 < g_{i+1}^1$ and $g_i^2 < g_{i+1}^2$, $i \in \{1,2, \dots, k-2\}$ assure that a higher number of parking places in P1 and P2 are reserved for higher priority classes. Constraints $\sum_{i=1}^{k-1} g_i^1 < N_1 - 1$ and $\sum_{i=1}^{k-1} g_i^2 < N_2 - 1$ assure that the total number of reserved parking places for the priority classes cannot reach the total number of parking places in P1 and P2, indicating that there would be some free parking places for Class k . Finally, constraints $g_i^1 > 1$ and $g_i^2 > 1$, $i \in \{1,2, \dots, k-1\}$ assure that at least two parking places are reserved for each priority class in P1 and P2. The solution of the MOO problem (4) provides the optimal parking places reservation policy $\mathbf{g}^* = (g_1^{1*}, g_2^{1*}, \dots, g_{k-1}^{1*}, g_1^{2*}, g_2^{2*}, \dots, g_{k-1}^{2*})$ that maximizes the total expected daily profit under the relative constraints for the blocking probabilities.

NUMERICAL ILLUSTRATION

We present a numerical application based on empirical data, where we consider $k = 4$ classes. Six different problem instances are examined based on the data presented in Table 1. Note that although in Table 1 the arrival and service rates are given in h^{-1} , for the appropriate computation, we have transformed these rates into d^{-1} , since we consider

that ticket prices c_i for Class i , $i = 1,2,3,4$ are given in c.u. per day. Table 1 provides also the optimal parking places reservation policy g^* which maximizes the $TEDP$ for selected values of the bounds $P_{b,Class i}^0$, $i = 1,2,3,4$.

Table 1 Input data and MOO results for 6 different problem instances

	(N_1, N_2)	$\lambda_{Class i}$ ($i = 1, 2, 3, 4$)	μ	$P_{b,Class i}^0$ ($i = 1, 2, 3, 4$)	g^*	$TEDP^*$	$P_{b,Class i}^*$ ($i = 1, 2, 3, 4$)
I1	(18,12)	(1.5, 2, 2.5, 3)	5	(10^{-4} , 10^{-3} , 0.05, 0.5)	(4,5,6,2,3,4)	1247.38	(1.82×10^{-10} , 9.07×10^{-5} , 0.026, 0.24)
I2	(20,16)	(1.2, 1.8, 2, 2.2)	4	(10^{-4} , 10^{-3} , 0.05, 0.5)	(5,6,7,2,3,4)	1051.38	(5.70×10^{-11} , 8.29×10^{-5} , 0.015, 0.11)
I3	(22,15)	(1.8, 2, 2.2, 3)	5	(10^{-4} , 10^{-3} , 0.05, 0.5)	(5,6,7,2,3,4)	1310.28	(3.60×10^{-10} , 7.06×10^{-5} , 0.014, 0.121)
I4	(15,12)	(5, 6, 7, 8)	20	(10^{-5} , 10^{-3} , 0.01, 0.1)	(2,3,4,2,3,4)	3875.84	(6.30×10^{-11} , 8.55×10^{-6} , 0.004, 0.06)
I5	(15,20)	(5, 6, 7, 8)	20	(10^{-5} , 10^{-3} , 0.01, 0.1)	(3,4,5,2,3,4)	3934.86	(7.05×10^{-13} , 1.89×10^{-7} , 0.00008, 0.001)
I6	(18,18)	(0.8, 1.1, 1.9, 3.2)	3	(0.0005, 0.005, 0.05, 0.5)	(4,5,6,2,3,4)	858.003	(3.85×10^{-11} , 6.01×10^{-5} , 0.04, 0.33)

Ticket prices $c_1 = 8, c_2 = 7, c_3 = 6, c_4 = 5$ (c.u./day)

Figure 2 Optimal reservation policy for different problem instances

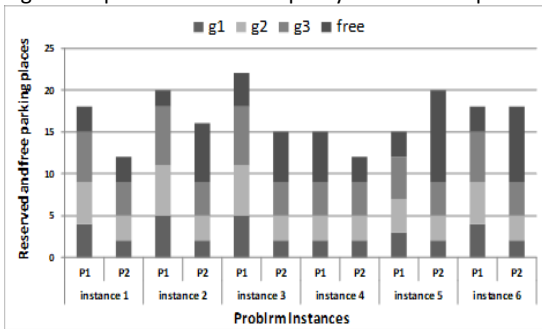


Figure 3 Variation of the optimal profit for various traffic cases

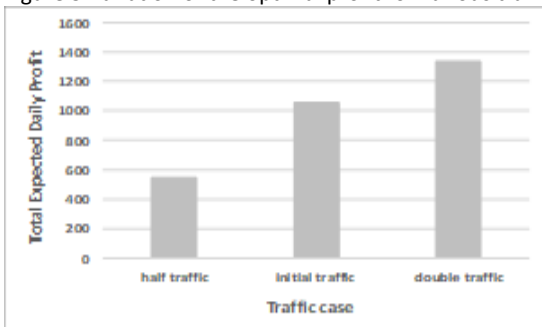


Figure 4 Variation of the optimal profit for various service rate cases (problem instance 2).

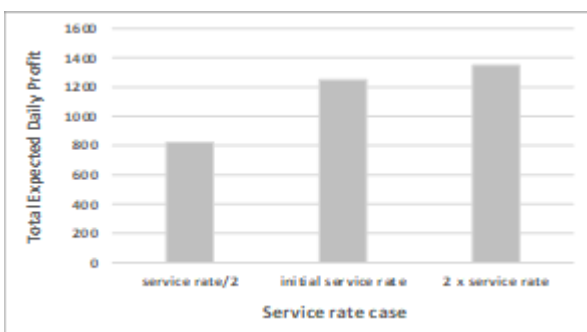


Table 2 Optimal solution of the MOO problem for instance 2 with respect to blocking probabilities' bounds

$P_{b,Class i}^0$ ($i = 1, 2, 3, 4$)	g^*	$TEDP^*$	$P_{b,Class i}^*$ ($i = 1, 2, 3, 4$)
(0.0001, 0.001, 0.05, 0.5)	(5,6,7,2,3,4)	1051.38	(5.70×10^{-11} , 8.29×10^{-5} , 0.015019, 0.110115)
(10^{-11} , 0.0001, 0.02, 0.2)	(4,6,8,2,3,4)	1050.46	(1.90×10^{-11} , 8.60×10^{-5} , 0.015585, 0.112967)
(5×10^{-12} , 0.0005, 0.02, 0.2)	(3,5,10,2,3,4)	1048.42	(2.70×10^{-12} , 1.19×10^{-4} , 0.017617, 0.118434)
(10^{-12} , 0.0005, 0.02, 0.2)	(2,5,11,2,3,4)	1046.96	(9.02×10^{-13} , 1.27×10^{-11} , 0.018809, 0.122662)

Table 3. Total Expected Daily Profit and blocking probabilities with and without reservation for instance 2

With Reservation					Without Reservation			
$\lambda_{Class\ i}$ ($i = 1, 2, 3, 4$)	μ	g^*	$TEDP^*$	$P_{b,Class\ i}^*$ ($i = 1, 2, 3, 4$)	λ	μ	$TEDC$	Blocking Probability
(0.6, 0.9, 1, 1.1)	4	(3,4,5,2,3,4)	542.4	(2.8×10^{-17} , 4.62×10^{-10} , 1.2×10^{-6} , 5×10^{-5})	3.6	4	561.6	2.74×10^{-8}
(1.2, 1.8, 2, 2.2)	4	(5,6,7,2,3,4)	1051.4	(5.7×10^{-11} , 8.3×10^{-5} , 0.01502, 0.11012)	7.2	4	1103.75	0.01731
(2.4, 3.6, 4, 4.4)	4	(2,3,4,2,3,4)	1335.3	(6×10^{-5} , 0.06959, 0.56148, 0.88785)	14.4	4	1247.99	0.44445
(1.2, 1.8, 2, 2.2)	2	(2,3,4,2,3,4)	667.6	(6×10^{-5} , 0.06959, 0.56148, 0.88785)	7.2	2	623.994	0.44445
(1.2, 1.8, 2, 2.2)	4	(2,3,4,2,3,4)	1335.3	(6×10^{-5} , 0.06959, 0.56148, 0.88785)	7.2	4	1103.75	0.01731
(1.2, 1.8, 2, 2.2)	8	(3,4,5,2,3,4)	1084.8	(2.8×10^{-17} , 4.6×10^{-10} , 1.2×10^{-6} , 5×10^{-5})	7.2	8	1123.2	2.74×10^{-8}

Table 1 provides the optimal values for the blocking probability for each clients' class too. In addition, Figure 2 provides a visual representation of the optimal reservation policy for each class and each parking lot, for all problem instances. In order to examine the effects of the arrival and the service rates on $TEDP$ we examine how $TEDP^*$ changes depending on these rates for instance 2. Hence in Figure 3, it is shown that, as expected, the daily profit of the managing company increases when the traffic at the parking lots increases. Moreover, in Figure 4, it is observed that as the service rate increases, $TEDP^*$ increases too, since in this case, parking places are dismissed more often, allowing hence more new clients to enter the parking lots. Additionally, we examine how the optimal reservation policy varies with respect to the bounds for the blocking probabilities, provided by the managing company, that reflects company's intentions for the number of accepted clients for each class. This is shown in Table 2, which depicts the change of the optimal solution with respect to these bounds. Beyond these, we examine whether the total expected profit is affected by the proposed approach. Thus, for instance 2 (similar results for all instances), where we consider that all clients belong to a unique class which pays a ticket price $c = 6.5c.u./day$ (mean value of the ticket price for 4 classes) to enter the parking lots. Table 3 presents the results for the $TEDP$ and the blocking probabilities with and without the parking places reservation; it can be observed that there are cases where the proposed approach provides higher daily profit and lower blocking probabilities, especially for higher priority classes. Consequently, a managing company intending to adopt the proposed approach, should perform an analysis to investigate if prioritizing clients and reserving parking places benefits the profit.

CONCLUSIONS

The paper considers a system consisting of two parking lots managed by the same company who aims in increasing its profit by the incoming clients. However, the profit strongly depends not only on the ticket price but of the number of incoming clients too. Thus, under a Markov model framework, we propose an approach for prioritizing incoming clients according to their privileges into different priority classes, and we propose to reserve parking places for the higher priority classes. The endmost aim is to increase the total expected daily profit for the company and simultaneously minimize the probability of service denial for each clients' class. This is done through a MOO problem. Finally, empirical numerical results indicate that the proposed approach can lead, depending on problem specifications, in higher daily profit and lower service denial probabilities.

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Session 24: Business and Society

chair: Emmanouil Steiakakis

Exploring the factors which impact the level of international students and international faculty members: The case of world-leading universities

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Abstract

The level of internationalization of universities proved to be a valuable tool which can attract the attention of various stakeholders, from beneficiaries to corporations looking for partnership. Therefore, universities are slowly, but surely starting to strategically act regarding their activities to attract international students and lecturers. Herein, we strive to explore the factors which impact the level of international students and faculty members on a world-leading university. To do so, we applied path analysis, a type of structural equation modelling (SEM) analysis. The analysis was applied on the data retrieved from the Academic Ranking of World Universities (ARWU) and QS World University Rankings for the year 2019. The suggested approach can provide insights on the mechanisms which attract international students and faculty members and can serve as a foundation for future research on the development of internationalization strategies of universities.

KEYWORDS

Universities, internationalization, international students, international faculty, path analysis.

INTRODUCTION

Nowadays, universities are competing in a global academic environment, as the number of global educational institutions and international students that enroll these type of studies increase (Bordogna, 2019). Studying abroad can be perceived as the international industry on one hand, as well as an experience that has a strong impact on students' life, in terms of linguistic, cultural, and personal development (Hajar, 2019; Thomas, 2020). Therefore, universities are encouraged to globalize and internationalize not only their courses and curriculums, whereas their teaching staff and students. Moreover, in past years, internationalization unfolded from marginal to a global, strategic, and mainstream component in higher education (Knight and De Wit, 2018).

Several studies have been conducted to explore the potential benefits of the internationalization of higher education (Arthur, 2008; Cantwell, 2015; Su and Harrison, 2016). International students represent the valuable input for universities (Amaro et al., 2019). They are the sign that a university has a global reach and diverse student body (Ford and Cate, 2020), and universities are developing policies and practices to attract international students, but also the faculty members, whose international mobility impacts their research careers (Cañibano et al., 2020). The rivalry for international students has pushed higher education institutions (HEIs) to strong marketing campaigns that have the aim to charm the potential students (Bamberger et al., 2020), where social media play very important role (Kuzma and Wright, 2013; Sleeman et al., 2016). It is also of utmost importance to enhance the international student mobility (Zimmermann et al., 2020) and international scientific mobility (Cañibano et al., 2020), as important educational means. Some authors emphasize negative aspects of internationalization (Dovchin, 2020). For example, the growth in international students, particularly at public universities, in some cases have caused disputes and conflict (Ford and Cate, 2020; Shih, 2017). Ford and Patterson (2019) have expressed their doubts regarding the reasons for diversity presentation on universities websites. Still, among various demands, universities strive to present international students as an institutional asset instead of controversial issue in higher education (Ford and Cate, 2020).

Sin et al. (2019) observe that there are four types of rationale for internationalization: cultural, political, academic, and economic. This study strives to analyse the academic indicators which impact the level of internationalization. Having all the presented in mind, policy makers and university representatives might be in need of an insight on how certain factors and activities attract or repel international students and faculty members. The focus of this research is in revealing those factors, as well as the nature and the strength of the suggested relationships among variables of interest.

The next section presents the proposed methodology of the research. It is followed by the research results and concluding remarks.

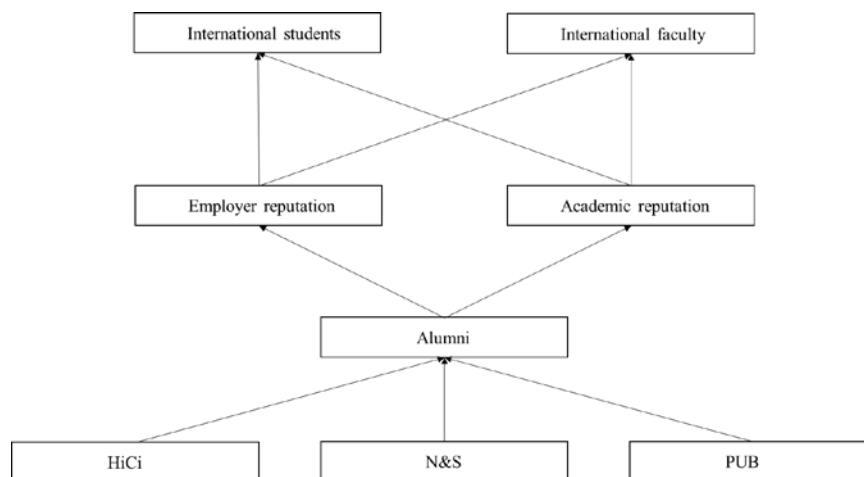
METHODOLOGY

To create and explore a conceptual model on internationalization, we decided to observe the world-leading universities. The data on which the model was tested was collected from the acknowledged university ranking lists: Academic Ranking of World Universities (ARWU) and QS World University Rankings for the year 2019. The dataset consisted of 61 universities which are ranked on both ranking lists. The output variables of interest are *International students* and *International faculty*, taken from the QS World University Rankings. The input and mediating variables of interest are *HiCi*, *N&S*, *PUB*, and *Alumni* taken from ARWU, and *Employer Reputation* and *Academic Reputation*, taken from QS.

2.1 Conceptual model on internationalization of world-leading universities

In this research, we strive to examine what was the impact of *Alumni* which received Nobel prizes on *Employer* and *Academic Reputation*, and the impact of *Employer* and *Academic Reputation* on *International students* and *International faculty*.

Figure 1. The proposed conceptual model



2.2 Suggested Methodology

To explore the relation between the observed indicators we opted for the Structural Equation Modelling (SEM), more precisely the Path analysis. The Path analysis have been used with a lot of success in the field of conceptual model verification. It is based on the principles of multiple linear regression. Thus, the analysis aims to evaluate causal models by examining the relationships between a dependent variable and two or more independent variables. To verify the quality of the model we used standard verification metrics: chi-square statistics, Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and root mean square error of approximation (RMSEA).

RESULTS

The descriptive statistics of the observed indicators is shown in Table 1. The indicator with the highest mean is *Academic reputation* followed by *Employer reputation*, with values of 87.917 and 82.058 respectively. Such result indicates that the top universities have a very good reputation based on the opinion of surveyed experts. The indicator with the smallest mean is *N&S*, followed by *HiCi*, with values 35.266 and 36.398 respectively. Having in mind that the values of the indicators are scaled compared to the best result, this indicates that the top scoring university significantly outperforms the rest of the universities. Indicator *International faculty* and *International students* have the highest

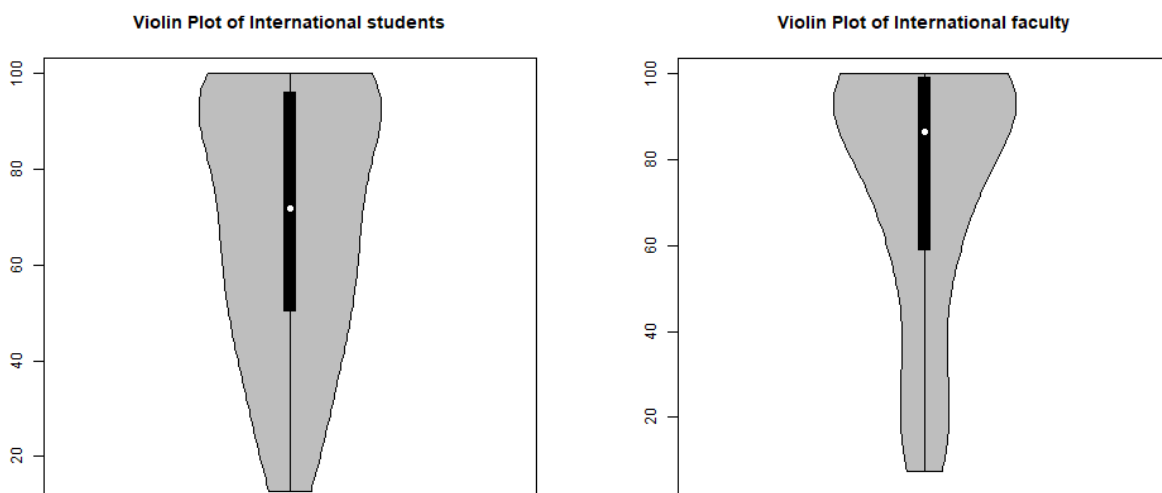
variance, indicating that the results of these indicators vary the most. We can conclude that even among the top universities, there are differences in the number of international faculty and students. Taking a closer look on the medians, we observed that the top ranked universities have high value of indicator *Academic reputation* with half of them scoring more than 92.750. The interquartile range (IQR) confirms that the values of *International faculty* and *International students* are more dispersed.

Table 1 Descriptive statistics of the chosen indicators

Indicator	Mean + Std	Median	IQR
HiCi	36.398 + 15.297	35.550	17.200
N&S	35.266 + 17.489	31.150	21.850
PUB	62.758 + 14.451	63.800	17.525
Alumni	26.538 + 21.517	20.600	24.625
Employer reputation	82.058 + 19.865	91.000	29.275
Academic reputation	87.917 + 14.054	92.750	20.675
International faculty	74.295 + 29.036	86.600	40.675
International students	69.425 + 26.713	71.900	47.625

We created violin plots of the indicators related to internationalization (Figure 2), that provide insights on the median, IQR, the lower and upper adjacent values, and the entire distribution of the data.

Figure 2 Violin plots of the indicators *International students* and *International faculty*



Next, we applied the path analysis. Overall fit of the initial model was marginally acceptable indicating that the initial model did not fit the data and that it had to be modified accordingly. The value of the chi-square statistics is 183.461 (df=19, 9.656, p=0.000). The RMSEA was 0.377, which was above the threshold of 0.1. CFI (0.358) and TLI (0.054) were well below the 0.90 threshold. To correct the model, we removed insignificant paths and used modification indices. Variables which did not have statistically significant impact on the outcome variables were removed.

In the final model, the value of the chi-square statistics is 9.671 (df=9, p=.000), while the chi-square/df ratio is 1.612, which is below the suggested threshold of 3 (Kline, 1998). The measured RMSEA is 0.100, which is at the threshold of 0.10 (Browne and Cudeck, 1993). TLI (0.943) and CFI (0.977) are above or well close to the recommended 0.90 threshold. We can conclude that the modified path model has a satisfactory fit. The model assessment is given in Table 2.

Table 2 Summary of causal effects in the final model and the obtained R square

Indicator	Predictors	Std Coeff	C.R.	R ²
Alumni	HiCi	-0.410**	-3.431	0.663
	N&S	0.999**	9.124	
Employer reputation	Alumni	0.662*	2.540	0.086
International students	Employer reputation	0.257*	2.150	0.097
International faculty	Employer reputation	0.312*	2.565	0.052

* p<0.05, ** p<0.01

In case of *Alumni*, from three initial predictors, two proved to be statistically significant: *HiCi* and *N&S*. The indicator *HiCi* interestingly has a negative path coefficient of -0.410 thus indicating that the more the institution has highly cited researchers, the less students will have won the prestigious awards. This result might indicate that on prestigious institutions which have highly cited researcher, they are more oriented towards their own research than teaching and inclusion of students into such research. On the other hand, the indicator *N&S* has a strong, positive impact. What can be concluded that the more papers researchers from an institution have published in reputable journals such as *Nature* and *Science*, the higher the probability of having alumni which will receive a prestigious prize. These two predictors explain 66.3% of variability of *Alumni* thus creating a model of good quality.

Regarding the model for *Employer reputation*, *Alumni* showed to be a significant predictor. The standardized coefficient is above 0.5, indicating a strong impact. The sole predictor explains 8.6% of variability of the reputation of employers thus indicating that the number of awards the alumni receive has an impact on the employers' opinion on the university, nevertheless they certainly have not had any previous contact with the ones who received the prize(s). Therefore, we can conclude that *Alumni* acts as a good WOM on employers.

Employer reputation at the same time acts as the sole predictor of both *International faculty* and *students* and explains 5.2% and 9.7% of variability, respectfully. This can be seen as a good result as one variable explains a solid part of variability. The obtained coefficients show that the higher reputation from the employers the institution has, the more international students and faculty members are interested in enrolling and working on it.

On the other hand, *Academic reputation* proved not have a statistically significant impact on the number of international faculty members and students. This comes as an unexpected result, as the opinion of academics and experts in scientific fields should have been detrimental for the decision on which university to enroll or to start/continue career. Nevertheless, we can observe that both students and academics care more to the opinion of employers and industry, than to colleagues.

CONCLUSION

It is very important for HEIs to be able to understand how international students and potential faculty members make their decisions regarding the university choice, and also what factors and sources of information mostly influence them, to create competitive marketing strategies for attracting them (Amaro et al., 2019; Briggs and Wilson, 2007). They are aware that, if the international studies decline, it is a sign of being ill prepared to address complex global challenges (Gentry and Stojek, 2020). Herein, the path analysis was employed to evaluate a novel conceptual model on the level of internationalization of world-class universities. According to the results, *Alumni* showed to be a significant predictor for *Employer reputation*, while *Employer reputation* is significant predictor of both *International faculty* and *International students*. Higher the reputation from the employers, more international students and members. *Academic reputation* does not significantly impact on the internationalization, leaving us with the conclusion that international students and academics are guided by the industry rather than peers. The proposed research puts an emphasis on the obtained results and on possible policy choices university representatives might make in order to attract international faculty members and students and, at the same time, improve their ranking results on the global level. During our research, we identified three possible future directions of the study. First, introduction of other indicators in the model, conducting Confirmatory Factor Analysis (CFA), and conducting panel regression.

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GAMIFIED MOBILE APPS IN HEALTH AND FITNESS

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Abstract

The concept of “Gamification” has become more and more popular. It is an innovative business model that focuses on applying game mechanics to non-game contexts in order to engage audiences and inject a little fun into daily activities; besides generating motivational, social, emotional and cognitive benefits. Developing positive social relationships and promoting a feeling of integration are the key social benefits noted for gamification. Typically, the various game mechanics potentially involved in gamification are regarded as an anchor point for players to ensure a flow of cognitive skills, such as achieving a state of concentration, developing problem-solving skills and acquire a sense of goal-orientation. Additionally, users bring out emotional skills, such as auto-satisfaction and self-esteem when they achieve a target. Gamification mechanics also motivate individuals to be more competitive in order to fulfill the challenges provided. The purpose of this paper is to present a set of the most well-known mobile health apps in fitness along with their basic features. A literature review of gamification systems in mobile health apps and particularly in fitness is presented. As evidenced by the literature review, gamification can help patients increase physical activity, improve eating habits and regulate body weight. Primary research shows that users are increasingly committed to gaming electronic health systems. In particular, the review of mobile gamified applications in the field of fitness revealed 20 applications with a good response from users, a large number of installations and good ratings. Although gamification is used in mobile health to some extent, the results of both the literature review and the mobile apps review are even more encouraging for the future. The initial results show a significant use of gamification in health and fitness applications, which requires in-depth study and evaluation of the gamification potential for a change in health behavior.

KEYWORDS

Gamification, gamification in mobile health, gamified mobile apps, fitness apps

INTRODUCTION

Gamification is a relatively new notion, as the first documented use dated back to 2008 and has begun to be adopted on a wide scale since the second half of 2010 (Deterding et al., 2011a). It is greatly based on the concept of games, which are designed first and foremost to entertain involved individuals and make them spend a lot of time and intense on them. On the other hand, gamification aims to get benefited from the elements of the game and make more attractive products and services with non-game context. As the term was greatly disputed from the video game and digital media industry; various designers originated other terms for their own practice to avoid the appearance of misconceptions about gamification (Deterding et al., 2011b). Thus, in order to provide an accepted definition, it can be deduced that gamification is an innovative business model that focuses on applying game mechanics to non-game contexts in order to engage audiences and inject a little fun into daily activities; besides generating motivational, social, emotional and cognitive benefits. Therefore, gamification targets to encourage people to participate, share and interact with an activity or a community; and provide an exciting, dynamic and constant experience which can be used from them in order to fulfill their diverse aims (Bunchball Inc., 2010).

According to McKeown (n.d.), gamification tries to create experiences similar to game via a mixture of game mechanics and game experience design. Rewards, such as achievement badges and points, are considered as a core gamification strategy for users who complete the tasks requested (Park and Bae, 2014). Setting challenges via task completion is another gamification strategy, which can be enhanced by making the tasks visible to other users (Park and Bae, 2014). Commonly, taking advantage of social networks with the aim to increase engagement and promote competition between users is another regular tactic (Palmer et al., 2012). There are also many other important gamification

mechanics, such as level improvement approaches, competitions, progress bars, narrative storylines, avatar-based self-representation, scoreboards, etc. (Cugelman, 2013).

The healthcare industry is one of the domains where gamification capabilities are applied. Specifically, the progress of the mobile technology and the considerably affordable cost for acquisition of a smartphone with advanced features, such as GPS, accelerometer, external sensors and internet access, have helped the development and adoption of gamified mobile apps in health as well (Lenihan, 2012; Sardi et al., 2017). This interest has also been attributed to the inequity access to healthcare resources, the lack of adherence to treatment and the increase in healthcare costs (Lenihan, 2012). Moreover the contemporary, highly competitive, way of living that stresses numerous people a lot, the bad eating habits, and the inactivity because of the lack of free time that can lead to serious health problems (Farhud, 2015). Thus, previous studies reported gamification in health and wellness contexts related specifically to chronic disease rehabilitation, physical activity and mental health (Sardi et al., 2017). As a result, several smartphone users take advantage of the gamified mobile health apps provided to motivate themselves, as well as avoid bad health and eating habits. The purpose of this paper is twofold. First, it aims to present a literature review of gamification systems in mobile health apps and particularly in fitness. Second, 20 popular gamified mobile apps in the field of fitness with a good response from users, a large number of installations and good ratings are presented and reveal gamification potential for a change in health behavior.

LITERATURE REVIEW

Up to now, there have been a number of researchers who have studied mobile health apps and provided a comprehensive review of these apps. The most cited papers are as follows. Souza-Júnior et al. (2016) evaluated the use of gamification in mobile health lifestyle-related apps. They revealed that the more gamification techniques an app has, the more accepted it is from smartphone users. Edwards et al. (2016) carried out a review and found out that only the 4% of the mobile health apps have gamification features. Additionally, these gamified apps use diverse gamification techniques to motivate individuals. Finally, Lister et al. (2014) revealed that despite the fact that mobile health apps have gamification features, they do not incorporate vital elements of the behavioral theory.

Regarding fitness apps, a relatively small number of researchers have investigated the influence of gamification in such apps so far. For example, Shameli et al. (2017) proved that walking challenges in a mobile app can increase the activity levels of users by 23%. Chen and Pu (2014) confirmed that mobile app users exercised more when they have to participate in challenge tasks than competition gamification mechanisms; and Hamari and Koivisto (2015) revealed that social influence have a positive impact on individuals' willingness to use gamified mobile fitness apps. On the other hand, Zuckerman and Gal-Oz (2014) tested a mobile fitness app with and without gamified features. They revealed that involved people had the same levels of physical activity in both versions. Thus, they believe that gamification does not force people to increase their activity.

METHODOLOGY AND RESULTS

The second scope of this paper is to present a number of gamified mobile apps in fitness (Table 1). Regarding the methodology applied for their selection, it was conducted based on the following criteria: a) the application should have been developed for android smartphones, b) has a good response from users, c) a large number of installations and d) good users' rating. Android smartphones were selected as the majority of individuals use this operating system on their mobile device (Statista, 2020). Regarding the other parameters, the rating cutoff value of 4.3 was applied. Moreover, selected apps should have at least 100,000 installations and more than 2,000 comments. It is expected that the combination of these cutoff values would reveal a subset of the most used and highly rated gamified mobile apps in fitness.

Based on these criteria a subgroup of 20 gamified mobile apps in fitness were selected and presented. Then, these apps were also categorized taking into consideration the area of their specialization and the gamification mechanics applied. Concerning their specialization area, they were classified in six categories: running, cycling, walking, diet, weight loss and workout. Regarding the gamification mechanics, they are actions, behaviors and control techniques which are used to gamify an activity. They determine the targets, the rules, the framework and the interaction types as well as the limits of the activity that is about to be gamified. These mechanics are already known before user's interaction with the app and remain the same for every user of the app. The most common gamification mechanics are: levels, scoreboards, challenges, achievement badges, accomplishments, competitions, virtual items and progress bars.

Table 1. Gamified mobile apps in fitness, as of August 2020

#	App's name	Specialization area	Number of installations	Rating – Number of Comments	Gamification mechanics
1	30 Day Fitness challenge	W, WL	10M	4.8 – 563K	AB, Ch, L
2	Nike Run Club	R	10M	4.6 – 993K	AB, Ac, Ch, Co, Sc
3	My Diet Coach – Weight loss motivation & tracker	D, W, WL	10M	4.5 – 148K	AB, Ch, PB
4	Lose it! Calorie counter	D, WL	10M	4.6 – 99K	Ac, Co, Ch, PB
5	Yoga for weight loss – Lose weight program at home	WL, Wo	1M	4.6 – 24K	AB, Ac
6	Runtopia – Rewards for run and walk, fit body, 10K run	R, W, WL	1M	4.6 – 30K	AB, Ac, Sc, VI
7	Adidas Runtastic running app and Run tracker	R	50M	4.6 – 1M	Co, Sc
8	Run with map my run	R	10M	4.7 – 273K	AB, Ch, Co, Sc
9	Walk with map my walk	W	5M	4.7 – 231K	AB, Co, Sc
10	Map my fitness workout trainer	Wo, R	1M	4.5 – 50K	AB, Ch, Co, Sc
11	Map my ride GPS riding	C	5M	4.6 – 153K	AB, Ch, Co, Sc
12	JEFIT workout tracker, weight lifting, gym log app	W	5M	4.4 – 72K	Ch, Co
13	Endomondo – Running and walking	R, W	10M	4.5 – 754K	AB, Ch
14	Step counter – pedometer free and calorie counter	W	10M	4.8 – 379K	AB, Ch
15	Running distance tracker +	R	5M	4.5 – 121K	Ch
16	Runkeeper – GPS track run walk	R, W	10M	4.4 – 558K	AB, Ch
17	Zombies, Run!	R, W	1M	4.3 – 21K	Ch, VI
18	Argus calorie counter diet, activity, step tracker	D, W	500K	4.3 – 5K	Ch, Co
19	Weight loss in 15 days, belly lose fat	WL, Wo,	100K	4.5 – 2.9K	Ch
20	Tabata HIIT Internal Timer	W, Wo	1M	4.6 – 15K	AB, Ch

Specialization area - C: Cycling, D: Diet, R: Running, W: Walking, WL: Weight Loss, Wo: Workout.

Gamification mechanics - AB: Achievement Badges, Ac: Accomplishments, Ch: Challenges, Co: Competition, G: Gifts, L: Levels, PB: Progress Bars, Sc: Scoreboards, VI: Virtual Items.

The results reveal that walking (11), running (9) and weight loss (6) are the most popular specialization areas of gamified mobile fitness apps followed by workout (4), diet (3) and cycling (1). Regarding the gamification mechanics applied; challenges (16) and achievement badges (13) top the list, followed by competition (9), scoreboards (7) and accomplishments (4). Virtual items (2), progress bars (2) and Levels (1) are slightly used on gamified mobile fitness apps.

CONCLUSIONS

Although gamification is used in mobile health to some extent, the results of both the literature review and the mobile apps presentation are even more encouraging for the future. The initial results show a noteworthy adoption of gamification in mobile fitness apps, where a considerable number of smartphone users exploit the gamification mechanics applied (Souza-Júnior et al., 2016). Users expressed their satisfaction about the functionality of these apps and utilize them in various areas (Souza-Júnior et al., 2016). According to the literature review, gamification can strengthen individuals' internal motives with the aim to change and improve their health behavior. Therefore, it goes without saying that gamification is expected to be incorporated even more on mobile fitness apps in the near future. Especially developers who take advantage of the behavioral theories that link psychological impact with gamification mechanics are expected to have even more prosperous prospects.

This study is the first, preliminary, part of an ongoing investigation to shed light on such a promising topic. As aforementioned these 20 mobile apps, which were presented, are a subset of a larger group of gamified mobile apps in fitness. Our future research aim is to deeper analyze them and reveal even more insights about their adoption, the level of their use, users' perceived benefits, their specialization areas, their gamification mechanics, as well as how gamified fitness apps change adopters' health behavior.

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Is Mass Production Feasible by Using 3D Printing?

The Use of 3D Printing in the Fight of Corona Virus Wave is an Indicative Case Study

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Abstract

The research question of this study is the integration of 3D printing technology in the manufacturing industry due to the pandemic Coronavirus. Initiatives around the world using 3D printing technology (professional AM providers and designers, universities and hobbyists) have responded to the global crisis by volunteering their skills and knowledge to ease the pressure on supply chains and governments and provide healthcare equipment for nursing staff.

The goal of this work is to show how 3D printing technology could be used for mass production with a different production model. We review the initiatives implemented worldwide using 3D printing technology in the fight against COVID-19 and map the structure of these initiatives. As in these initiatives, the production took place in workstations, scattered in different geographical areas, a new procedure structure probably will arise.

KEYWORDS

3D printing; COVID-19; Manufacturing Industry.

INTRODUCTION

Additive manufacturing (AM), often colloquially referred as to 3D printing (3DP), creates physical objects from a geometrical representation by successive addition of material (ISO/PRF 17296-1, 2015). The AM term describes the use of a collection of technologies capable of joining materials to manufacture complex products in a single process step, directly from 3D data. Although AM was primarily used for making prototypes, the development of material science and manufacturing technologies enabled producing parts directly using AM technology. 3DP technology enables the production of a wider variety of products, most of which are custom-made products, without incurring any additional manufacturing costs. Theoretically, through 3DP technology and because of layer-by-layer manufacturing process, any physically feasible product design compiled in a 3D model can be produced, with no limits in complexity (Weller *et al.*, 2015).

3DP has a wide range of applications in medicine, education, science, culture, architecture, marketing and aerospace. Items, such as body organs, human tissues, upper and lower limbs, orthopedics, dentures, dental implants, guns, toys, shoes, jewelry, statues, and components for the automotive and aerospace industries can be produced using additive manufacturing (Rankin *et al.*, 2014; Martorelli *et al.*, 2013; Hopkinson *et al.*, 2003). The decision to invest in 3DP technologies must be linked to product characteristics and the addressed market; customized products; products with increased functionality through design optimization; products of low volume (Murmura and Bravi, 2018; Mellor *et al.*, 2014).

An open question in literature concerning 3DP technology is related with the mass production. How feasible is to produce objects of large volume by using 3D printers. In order to answer in this question we examine the case study arising from the recent pandemic wave of coronavirus and the number of initiatives that had been developed in order to produce personal protective equipment (PPE).

Since March 2020, professional AM providers and designers, universities and also hobbyists in the 3DP community, have already responded to the global crisis by volunteering their respective skills to ease the pressure on supply chains and governments. Using new technologies, their scientific knowledge, their equipment but mostly with the satisfaction of making a positive contribution, hundreds of volunteers are supplying their country's nursing staff with health care equipment to protect them on their duty to hospitals. Initiatives and collaborations using 3DP technology in the battle against COVID-19, supporting local health efforts can be lifesaving. AM may be able to play a role in supporting industrial

supply chains that are affected by limitations on traditional production and imports and 3DP can have an immediate beneficial effect when the supply chain is disrupted (Sher, 2020).

The goal of this work is to present how 3DP technology supports both mass production and customized production based on end users needs. We examine the case study of pandemic wave where, large number of healthcare equipment had been printed and equipment that satisfy health caregivers needs. The remainder of this paper is organised as follows Section 2 presents a brief review of 3D printing aspects. Section 3 presents the worldwide initiatives of 3D printing industry in the fight towards COVID-19. Section 4 presents the new production model. Finally, Section 5 summarises the conclusions of this work and suggests further research.

REVIEW OF 3D PRINTING ASPECTS

The benefits of 3DP methodology include new design freedom, removal of tooling requirements and economic low volume. Customized products, products with difficult geometries and components of products from scratch can now be designed and printed with AM. Small or big markets can be served without requiring companies to warehouse or produce goods at large costs. The result of this technology is the redefinition of production systems as the new production line is the combination “Design-Sales-Printing”. Moreover, the use of personal 3D printers could not only change the manufacturing methods but could also reshape business processes from the design of an object to its consumption.

3DP technology allows to the customer (as an individual or as a business) to have customized products without incurring any cost penalties in manufacturing. AM allows to produce components and final goods directly from a 3D data, without the use of tooling or other setup cost (Kleer and Piller, 2019). 3DP reduces time and costs, from the design period to manufacturing period, since there is limited investment in designing and manufacturing the necessary fixtures. 3DP allows economical custom products, with small production batches and the potential for simpler supply chains and shorter lead times.

INITIATIVES OF 3D PRINTING INDUSTRY

In the last months, numerous initiatives have developed in Europe and USA to support the production of urgently needed health care equipment and spare parts (3D Face Shields, Surgical Mask Strap, 3D Respirator Valves, printed adapters to turn snorkeling mask into a non-invasive ventilator) in the fight against pandemic coronavirus. Hospitals and healthcare systems around the world are going to experience an immense strain, and they will need machines, devices and parts to help save lives. 3DP can provide these critical parts when supply chains are disrupted or broken. The impact of COVID-19 in Italy has caused regional shortages of key equipment, such as masks and hoods for non-invasive ventilation in respiratory support. There are many encouraging examples that reducing the fear that has been caused by the COVID-19 outbreak all over the world. The following overview summarizes some examples of initiatives and platforms that established across Europe and USA and provide hospitals and health care staff with PPE.

3D Makers.gov.gr (Greece): An initiative of the Ministries of Digital Governance and Health. It acts as a bridge between the urgent needs that exist today in the field of Health and potential solutions by creating and providing equipment (manufacturing face protection shields and hands-free knobs “Materialise”) developed by initiatives from citizens, groups and organisations that are daily assisting as 3d-makers in the effort to stop the pandemic in Greece.

Hellas COVID19 3D Printing Supplies (Greece): In collaboration with the Ministry of Health, the voluntary group of 3D printers of protective shields prints protective shields for the country's medical and nursing staff. With a team of about 1,850 members, there is a total of 350-370 3D printers available to print this personal protection following a design approved by the Ministry of Health of Greece.

America Makes (USA): A joint effort with the FDA, NIH, and VA to be the bridge connecting the need for medical PPE with manufacturers capable of 3D printing safe PPE for medical providers and designers willing to share 3D print designs. This initiative is connecting manufacturers with printable designs being reviewed for clinical use to ensure the delivery of safe PPE for medical caregivers on the front-line of the COVID-19 pandemic.

Unite4COVID (Holland): A collaborative marketplace that offers approved solutions for fighting the virus, sourced from around the globe, and serves as a space to develop new solutions to help relieve the urgent need for medical supplies, equipment and replacement parts.

Prusa Printers (Czech Republic): This initiative for printing protective face shields has turned into a massive endeavor worldwide. The Prusa face shield is a type of enlarged face mask that covers the entire face, has an ergonomic design and is reusable after being appropriately disinfected, the absolute necessity of which is highly stressed by the manufacturer. In only three days after the development of the prototype, dozens of prototypes printed.

3Druck.com – Coronavirus (Austria): Initiative of the Austrian Technology Platform AMA on 3D printing technology resources for corona prevention devices with survey for enquiries and for offers.

Siemens AM Network Platform (Germany): Siemens opened their AM Network Platform to everyone who requires medical device design or print services. Through the network, designers and suppliers can be reached worldwide to prepare parts.

3D Printing Fights Corona (Germany): 3D Printing fights Corona is an initiative of MGA together with its members and different key AM market players to build up the necessary infrastructure. Recent requirements and potential solutions are discussed in virtual sessions.

CRP Technology on the front line in the fight against Covid-19 (Italy): Italy-based company that manufactures emergency valves for assisted ventilation with the help of Additive Manufacturing and Windform® P1 isotropic material.

Przyłbice 3D dla lekarzy - okręg Wrocław (Poland): Facebook group for collaboration in 3D printing that aims to produce medical protective equipment that can be used by doctors during Covid-19 pandemic.

Wrocław University of Science and Technology supports production of medical protective equipment (Poland): Wrocław University of Science and Technology and the Center of Advanced Manufacturing Technologies activated 3D printing devices and optimized face shield design that can be used by activists and volunteers in the surrounding area. In addition, connectors for ventilation masks are produced.

Until today we don't know the exact number of equipment printed all over the world during the period March to May. It is remarkable that more than 86.000 pieces had been printed at France, 25.000 pieces had been printed at Greece.

THE NEW PRODUCTION MODEL

Adopting new digitized production, service and interaction models that focus on personalization reduces inefficiencies in the production process, costs to meet personalization needs, costs of the supply chain and leads to new targets where Industrial Revolution 4.0 can satisfy increasingly demanding customers who want efficiency coupled with speed while looking forward to innovative value-added services.

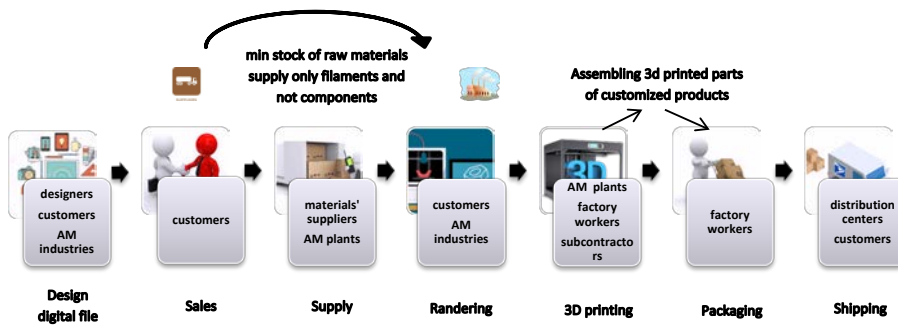
By adopting new production models such as 3DP, the need to produce customized products is fulfilled, while at the same time the costs for producing these products are largely manageable (Popkova *et al.*, 2019). 3DP has been recognized as a disruptive technology for future advanced manufacturing systems. With a great potential to change everything from our daily lives to the global economy, significant advances in 3D printing technology have been made with respect to materials, printers, and processes. A few sectors, like hearing aids, have switched their entire manufacturing process from traditional to additive manufacturing within a short timeframe (Baumers and Holweg, 2019).

Using 3DP specifically to create very complex components can be an economically viable alternative to conventional production technologies. In 3DP, the classic stages of design, production and sales change. Traditional demand models are no longer valid, as products are manufactured on demand. The life cycle of products changes. The cost of production is reshaped as the production process becoming simpler. Even if the process costs may be higher than traditional manufacturing methods at this stage, the technological process can reduce other type of costs, such as inventory and warehouse costs (Chan *et al.*, 2018). 3DP production can be started on a made-to-order basis and as a result the inventory stocking due to uncertain demand along a supply chain, will be reduced. The development and spread of this technology has prompted businesses to look for growth strategies that will differentiate them. AM technology creates new opportunities for the economy and society.

A 3DP process network comprises multiple entities and connections among entities. More specifically, a 3DP network consists of customers, suppliers, 3DP manufacturing plants, workforce (including designers), 3D printers, distribution centers and business partners, as well as the links among these entities, through which printed goods flow.

In Figure 1, we present a typical and comprehensive 3DP process network that involves all physical and nonphysical stakeholders (i.e. customers, AM industries) and presents all phases of this network. More specifically, at the first step, a digital file is sketched, as an AM industry advertises the product and then customers buy digital files in order to have 3D printed customized products. 3D printed objects are produced (printed) after they have been sold so sales are in the second stage (Mavri, 2015). At the third step, the AM industry supplies the necessary materials. Before printing the object, a rendering of the customized product is necessary. Finally, the AM industry examines the quality of the printed object, then packs the product and ships the product to the customer via post or e-mail (if the customer orders only sketches).

Figure 1. Graphical representation of a typical 3DP network (stages step by step and involved entities)



We claim that the initiatives described above used this operation structure (Demand-Design; Print-Manufacturing; Supply-Distribution).

Demand from Hospitals for the needs of specific health care equipment (i.e. valves or face shields). One of the biggest immediate problems that coronavirus is causing is the massive number of people who require intensive care and oxygenation in order to live through the infection long enough. The Ministries of Health collect the requests of hospitals and local health centers.

Approved **design** sketches from AM designers / makers such as Prusa's face shields or "Materialize" 3D printed door opener. Face shields are designed for optimal productivity, parts per build and output with 3DP technology, with a minimalist design. Face shield frame is designed for optimal comfort and to help the face shield stay in place. The initiatives all over the world can download the approved from the Ministries of Health free digital files.

3D Printing the requested health care equipment, using the capacity (numbers of 3D printers, hours of printing) that professional AM makers, universities and hobbyists already own. To ensure the best fit, customization (the main principle in 3DP technology) of masks may be achieved by printing in several sizes, experimenting with flexible materials, or surface scanning intended users' faces (Tino *et al.*, 2020).

Professional AM providers **supply** the initiatives with required filaments without charge. The number of suppliers can be reduced drastically due to the flexibility 3DP can deliver. In an extreme scenario, the only supplier would be the materials supplier for the 3DP process during the production phase (Chan *et al.*, 2018; Mellor *et al.*, 2014).

Quality checking of the collected health care equipment in inventory centers by the Ministries of Health.

Distribution of the requested health care equipment to the hospitals and local health centers according to their needs. 3DP is a decentralized manufacturing technique that will alter distribution network. 3D printers are installed close enough to the final customer (i.e. hospitals) and this enables the supply chain to avoid transportation and inventory holding costs.

After describing the operation model of these initiatives, we proceed to the question related to cost of printing objects instead of manufacture them.

Baumers and Holweg (2019) stated that there are three types of costs associated with adopting 3D printing technology: (a) the 3D printers purchasing cost; (b) the 3D design investment cost which is a fixed cost, independent of the number of products being 3D printed and (c) the 3D printing variable cost, which is the cost of material/filament as well as energy costs, which are a linear function of the number of products being 3D printed.

In this structure, initiatives have already owned a number of 3D printers (located at the same geographical area or to different areas and the printed object are delivered to a specified work center) and the approved design sketches can be free downloaded. Thus means that initiatives have only to deal with the energy cost.

The last question deals with throughput or printed objects. Throughput may be the most challenging factor concerning the volume of production. Some of these models require several hours to print on conventional desktop printers, while many 3D printing laboratories can parallelize this process with multiple printers, throughput will likely remain limited to dozens of masks per printer (Tino *et al.*, 2020). When production is parallelized with multiple printers, scattered in different geographical areas, even in other country, 3DP can be used for a larger volume of production.

CONCLUSIONS

In this study we tried to answer to the open question of mass and customized production by using 3DP technology. We examined the case study of initiatives, which had been developed all over the world during pandemic coronavirus wave, in order to answer if it is possible to print large volume of products using 3D printers. We examine these initiatives in terms of (a) operations' structure, (b) cost and (c) throughput of products. Although we conclude that mass and

customized production is feasible based on this new technology, some other issues are emerged and have to do with: the rapidness of production and the difficulty of following specific quality requirements and the intellectual properties of printed objects (as it is very easy to produce a new object based on minor modifications to initial design, problems with intellectual property arises). Thus, we suggest that new regulations concerning the quality of printed objects and the intellectual property of objects are necessary in order to take advantages of AM.

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Session 25:
Multiple Criteria Decision Analysis
chair: Nikolaos Tsotsolas

Tourists' satisfaction by local foods' consumption in Greece: a MUSA application

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Abstract

This research aims at investigating tourists' satisfaction by local foods consumption in Greece. Through Multicriteria Satisfaction Analysis (MUSA method) the link, between tourists' satisfaction by local foods consumption and tourists' attitudes towards local foods, is investigated. MUSA, a multicriteria decision analysis method, is used as an ordinal regression-based preference disaggregation technique which measures and analyzes customers' satisfaction. MUSA is utilized for the estimation of the contribution (importance) of tourists' attitudes towards local foods to the satisfaction by local foods' consumption. The survey took place at July to October 2018 in Thessaloniki where 311 properly answered questionnaires were collected by tourists at the Airport Macedonia. The criteria used were taste, health, safety, nice smell, authenticity, quality, inexpensiveness, nice appearance, nice package, connection to Greek culture and enhancement to Greek economy. The criterion obtaining the strongest weights is taste, followed by safety, nice smell, authenticity, nice appearance and connection to Greek culture that obtain the same weight, while the criterion with the weakest effect is inexpensiveness. Tourists are not strongly demanding regarding the selected criteria as all demanding indices are negative. The attributes with the strongest performance are taste, nice smell, authenticity, safety and connection to Greek culture, while the overall average performance of satisfaction by Greek foods' consumption obtains a high score as well. Results suggest that tourists' satisfaction, regarding local foods, is mostly affected by sensory traits, followed by authenticity, cultural traits, and safety.

KEYWORDS

tourists, tourism food consumption, local foods, Greek foods, MUSA, multi-criteria analysis

INTRODUCTION

Tourism could be described as one of the most important parts of Greek economy. Tourism's contribution to Greek GDP was 27.3% at 2017 (SETE, 2017), 30.9% at 2018 (SETE, 2018) and 20.8% at 2019 (WORLD TRAVEL & TOURISM COUNCIL, 2020). The contribution of the tourism sector in total employment in Greece was 24.8% at 2017 (SETE, 2017), was 25.9% at 2018 (SETE, 2018) and 21.7% at 2019 (WORLD TRAVEL & TOURISM COUNCIL, 2020). Thus, both by terms of employment and GDP tourism is vital for Greek economy.

Food's role during holiday is multi-dimensional (Tikkanen et al., 2007). It can be the main inspiration to visit a destination (López-Guzmán et al., 2017; Sánchez-Cañizares & Guzmán, 2012), a major part of expenses during holiday (Kim, et al., 2009), a way to connect with local culture (Björk & Kauppinen-Räsänen, 2016), and an exciting experience during holiday (Kim et al., 2009). Furthermore, local foods' consumption can be a sustainable tourism experience as it enhances local economies and society (Sims, 2009). Tourists are categorized by Björk and Kauppinen-Räsänen (2016) to three main categories with regard to local foods consumption: those whose main travelling motivation is local foods' consumption (the experiencers), those who are positive regarding consuming local foods (the enjoyers) and those who are indifferent towards local foods (the survivors).

There are several motivators regarding local foods' consumption. Taste and smell are sensory traits that motivate tourists for local foods' consumption (Kim et al., 2009; Mak et al., 2012). Foods' visual image is both a motivator for local foods' consumption (Kim et al., 2009; Mak et al., 2012) and a satisfaction indicator (Peštek & Činjarević, 2014). Tourists are authenticity seekers (Cohen & Avieli, 2004) and seek to connect with local and national culture through

local foods' and cuisine (Björk & Kauppinen-Räsänen, 2016; Chang et al., 2010). Health and safety issues are raised among tourists (Kim et al., 2009; Mak et al., 2012) as food can also act as an impediment (Cohen & Avieli, 2004). Local community's sustainability and welfare can be also important for tourists who regard themselves as responsible for their host country (Sims, 2009). Taste, Quality, Authenticity and Local Originality were found by Altintzoglou et al. (2016) to be the main motivators for food purchase during holiday. Regarding tourists' satisfaction quality, price, cultural heritage, image, health benefits and uniqueness were found to be the main indicators (Peštek & Činjarević, 2014). The scope of the paper is to link tourists' attitudes towards local foods with tourists' satisfaction by Greek foods consumption. In order to achieve this, the Multicriteria Satisfaction Analysis (MUSA) method will be used. MUSA, a multicriteria decision analysis method, is used as an ordinal regression-based preference disaggregation technique which measures and analyzes customers' satisfaction.

METHODOLOGY

At June 2018, a structured questionnaire was developed and distributed from July 2018 to September 2018 at Macedonia Airport of Thessaloniki. The questionnaire was translated at English, German and Russian. The questionnaire had three distinct parts but for this research, only questions from the second and the third parts will be used. The second part obtained five-point likert scale questions about consumption of local foods by tourists. The third part obtained demographic questions. Convenience sampling was utilized for gathering the data. Consumer surveys on tourist sector use this sampling technique as other methods are very difficult to apply. The final sample consisted of 311 properly answered questionnaires ($n = 311$).

In order to answer the scope of the research, which is to investigate the link between tourists' satisfaction by local foods consumption and tourists' attitudes towards local foods, MUSA method was utilized. It was developed by Grigoroudis and Siskos (2002) as a multicriteria decision analysis method that uses an ordinal regression-based preference disaggregation technique which measures and analyzes customers' satisfaction. The method has been used in a variety of studies regarding costumers' satisfaction, employee's satisfaction, web users' satisfaction etc. (Grigoroudis et al., 2008; Grigoroudis & Siskos, 2003; Manolitzas et al., 2014; Mihelis et al., 2001; Siskos et al., 1998).

In this technique, a collective value function Y^* and a set of partial value functions X_i^* are assumed. The method aims at achieving the maximum consistency between those functions. Partial value functions X_i^* are referring to consumers' satisfaction on a specific attribute, while function Y^* to the overall consumers' satisfaction. By introducing a double-error variable to the ordinal regression equation:

$$\hat{Y}^* = \sum_{i=1}^n b_i X_i^* - \sigma^+ + \sigma^- \quad (1)$$

\hat{Y}^* is the estimation of the global value function (Y^*), n is the number of criteria used in the analysis, b_i is the weight of the i -th criterion, while σ^+ and σ^- are the overestimation and underestimation errors, respectively. The sum of weights $\sum_{i=1}^n b_i$ is equal to one. Both global and partial functions, Y^* and X_i^* , are monotonic and normalized in the interval $[0,100]$. In order to assure monotonicity, MUSA uses the following transformation equations:

$$z_m = y^{*m+1} - y^{*m} \quad m = 1, 2, \dots, \alpha - 1 \quad (2)$$

$$w_{ik} = b_i x_i^{*k+1} - b_i x_i^{*k} \quad k = 1, 2, \dots, \alpha_i - 1 \quad \text{and} \quad i = 1, 2, \dots, n \quad (3)$$

where α and α_i are the number of levels of global and partial functions, x_i^k is the level of criterion i ($k = 1, 2, \dots, \alpha_i$) and x_i^{*k} is the value of x_i^k , y^{*m} is the m level of total satisfaction ($m = 1, 2, \dots, \alpha$) and y^m the satisfaction level.

In order to estimate the model through linear programming optimization problem can be re-written as:

$$[min]F = \sum_{j=1}^M \sigma_j^+ + \sigma_j^- \quad (4)$$

which is subject to:

$$\sum_{i=1}^n \sum_{k=1}^{x_i^j-1} w_{ik} - \sum_{m=1}^{y^j-1} z_m - \sigma_j^+ + \sigma_j^- = 0 \quad \text{for} \quad j = 1, 2, \dots, M \quad (5)$$

$$\sum_{m=1}^{\alpha-1} z_m = 100 \quad (6)$$

$$\sum_{i=1}^n \sum_{k=1}^{\alpha_i-1} w_{ik} = 100 \quad (7)$$

$$z_m, w_{ik}, \sigma_j^+, \sigma_j^- \forall m, i, j, k \quad (8)$$

M is the size of the sample, x_i^j , y^j are the level in which the independent variables X_i and the dependent variable Y are estimated (j -th level).

The problem of model stability is solved through a post optimality analysis. The constraints of the linear program generate the polyhedron of multiple or near optimal solutions. The final solution is given by performing n linear programs with the following form:

$$[max]F' = \sum_{k=1}^{a_i-1} w_{ik} \quad \text{for } i = 1, 2, \dots, n \quad (9)$$

which is subject to the following constraints:

$$F \leq F^* + \varepsilon \quad (10)$$

And all the constraints (5), (6), (7), (8)

At (10), ε is considered to be a small percentage of F^* . The final solution is the average of solutions given by the performance of n LPs (9). The greater the stability is, the more representative the average solution is.

MUSA can also generate global and partial performance indices and demanding indices to define overall satisfaction, each criterion's performance and demanding levels of customers for each criterion. The following equations are used:

$$\text{Global Satisfaction Index: } S = \frac{1}{100} \sum_{m=1}^a p^m y^{*m}$$

$$\text{Partial Performance Index: } S_i = \frac{1}{100} \sum_{k=1}^{a_i} p_i^k x_i^{*k}$$

$$\text{Overall Demanding Index: } D = \frac{\sum_{m=1}^{a-1} (\frac{100(m-1)}{a-1} - y^{*m})}{100 \sum_{m=1}^{a-1} \frac{m-1}{a-1}} \quad \text{for } a > 2$$

$$\text{Partial Demanding Index: } D_i = \frac{\sum_{k=1}^{a_i-1} (\frac{100(m-1)}{a_i-1} - x_i^{*k})}{100 \sum_{k=1}^{a_i-1} \frac{k-1}{a_i-1}} \quad \text{for } a > 2 \text{ and } i = 1, 2, \dots, n$$

Where p^m and p_i^k stand for the percentage of customers that belong to level of satisfaction y^m and criterion level x_i^k , accordingly.

Both the dependent (satisfaction by local foods' consumption) and the independent variables (attitudes towards Greek foods) were measured at five-point likert scales.

For this analysis 11 criteria were chosen. The criteria selected were: 1) Taste, 2) Healthiness, 3) Safety, 4) Nice smell, 5) Authenticity, 6) Quality, 7) Inexpensiveness, 8) Nice appearance, 9) Nice package, 10) Connection to Greek culture, and 11) Enhancement to Greek economy. These criteria are tourists' attitudes towards Greek foods and they were selected through relevant literature.

RESULTS

The final sample consisted of 311 respondents. The majority of the respondents were women (55.2%), obtained a university degree (81.67%), of German nationality (35.37%), with monthly income over 3.000 euro (33.76%) and the mean age was 38 years old.

At Table1 the main results of MUSA are presented. The overall satisfaction level of tourists by Greek foods' consumption is quite high, obtaining a performance index of 88.57%. Taste, Nice Smell and Authenticity are obtaining the greatest performance index, while the least strong are obtained by Nice Package, Inexpensiveness and Enhancement to Greek Economy. Regarding the importance of each criterion, the greatest importance for tourists' satisfaction is obtained by Taste which has the strongest weight (20.3%). Secondly, five criteria, Safety, Nice Smell, Authenticity, Nice Appearance and Connection to Greek Culture, hold the same weight (9%). The least levels of importance are obtained by Inexpensiveness (6.1%), Nice Package (6.2%), Enhancement to Greek Economy (7.2%), Healthiness and Quality (7%). Tourists in Greece have a low-medium demanding level towards local foods regarding the selected criteria as all demanding indices are negative.

Table 1 MUSA results

Criteria	Weight (%)	Performance Index	Demanding Index
Taste	20.3	96.03	-67.77
Healthiness	7.2	77.49	-17.39
Safety	9	85.28	-33.77
Nice smell	9	87.08	-33.73
Authenticity	9	85.6	-33.76
Quality	7.2	75.36	-17.39
Inexpensiveness	6.1	65.95	-02.92

Nice appearance	9	81.76	-33.79
Nice package	6.2	57.29	-03.39
Connection to Greek culture	9	83.71	-33.7
Enhancement to Greek economy	7.2	73.16	-17.39
Overall satisfaction		88.57	-37.97

Source: Authors' research

CONCLUSION

This study analyzes tourists' attitudes towards Greek foods according to their importance for tourists' satisfaction by Greek foods' consumption. Tourists regard local foods mostly as tasty, with nice smell and authentic. Generally, tourists are highly satisfied by Greek foods' consumption. The strongest influence to tourists' satisfaction is obtained by taste while it is also the attitude with the strongest performance index. Second in importance are Safety, Nice Smell, Authenticity, Nice Appearance and Connection to Greek Culture. Inexpensiveness, Nice package, Healthiness, Enhancement to Greek Economy and Quality obtain the smallest importance. Regarding the selected criteria tourists are not strongly demanding.

Tourists in Greece regard sensory traits as the most important regarding their satisfaction by local foods. Connection to Greek culture and authenticity, which regard the non material cultural traits of foods are also contributing a lot to tourists' satisfaction. Visual image of food and Safety are highly estimated regarding their contribution to satisfaction, as well. Thus, the most important contributors for tourists' satisfaction are sensory appeals, visual image and connection to local culture. Price, package, quality, enhancement of local economy and health issues are not considered so important for tourists' satisfaction. Consequently, extrinsic characteristics (price and package) are not contributing a lot to tourists' satisfaction.

This research offers both academic and entrepreneurial contributions. It is contributing to the existence literature by ranking tourists' criteria for local foods consumption. There is a vast literature regarding motivators for local foods consumption and satisfaction, but through MUSA method these attributes will be ranked according to their importance (weight). As far as the authors are concerned this is the first time this methodology (MUSA) is used regarding local foods' research in tourism. Regarding entrepreneurial implications, results suggest that both material and non-material dimensions of local foods contribute greatly to tourists' satisfaction. Local agri-business entrepreneurship can benefit from these results to meet tourists' requirements. The strongest emphasis must be given to sensory traits and especially taste. Furthermore, foods' connection to Greek culture and authenticity should be communicated to tourists as part of the non-material food's dimension. Foods' appearance is important together with safety.

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Critical success factors of digital maturity: a multicriteria analysis

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Abstract

A successful digital transformation is vital for organisations in the service industry. Although many prior studies have raised its importance and value, managers and decision-makers still focus on the implementation of information systems and applications denying to shift their thinking towards digital maturity and more strategic decision-making. The purpose of this research is to recognize and prioritize the factors of a successful digital transformation. In order to achieve this proposition, a digital maturity model has been designed focusing on a better understanding of digital transformation management. The identification of critical success factors was conducted by implementing a multicriteria methodology. Data was gathered via a structured questionnaire from professionals knowledgeable about digital transformation initiatives in a sample of Greek small and medium service enterprises (SMEs). Finally, the implementation of a multicriteria methodology examines the potential validation of a predictive model for more successful digital transformation strategies, based on a set of critical factors.

KEYWORDS

Digital Maturity Model, Digital Transformation, Digital Strategy, Multicriteria Analysis, Success Criteria

INTRODUCTION

The forth industrial revolution has caused disruption in the business ecosystem. Several organizations are into their digital transformation journeys and most of them are looking to measure their progress, assess their maturity, and benchmark against other firms in their industry (Kitsios and Kamariotou, 2016a; Kitsios and Kamariotou, 2016b). They are trying to understand: how to assess this digital maturity, which are the key success factors, and which are the new capabilities that they need to master. Digital transformation is a wide topic and requires competency across strategy and vision, process and governance, people and culture, and technology and capabilities (Henriette et al., 2016; Kitsios and Kamariotou, 2019; Mitroulis and Kitsios, 2019a; Mitroulis and Kitsios, 2019b; Vial, 2019). Therefore, digital maturity models are very important both for decision-makers and employees. They are used in order to present the status quo of digital transformation and they could provide a clear roadmap for the digital transformation strategy. During the last decade, many different digital maturity models have been developed in order to conceptualize and assess the digital maturity of organisations. Additionally, they also reveal the intension to effectively manage, guide and prioritize digital transformation initiatives. Many prior attempts were made to design and implement various digital maturity models, however, there is still a lack of understanding on which are the most commonly used maturity dimensions and which of their variables are the most critical success factors (Berghaus and Back, 2016; Schumacher et al. 2016; von Leipzig et al., 2017; Valdez-de-Leon, 2016).

The main objective of this paper is to recognize and prioritize the factors of a successful digital transformation. In order to achieve this proposition, a digital maturity model has been designed focusing on a better understanding of digital transformation management. For this purpose the dimension of the most recent digital maturity models were explored and UTADIS method was applied leading to a prediction model based on multicriteria decision analysis (MCDA).

The rest of the study is organised as follows: Section 2 reviews and discusses prior researches related to digital maturity models, gathering the needed literature. Section 3 describes the research methodology and the data analysis. Section 4 presents the attained results. Finally, Section 5 shows the conclusions of the study and proposes some future research directions.

LITERATURE REVIEW

Most of the times digital maturity and digital transformation are used interchangeably. However, digital maturity is actually a more systematic way to achieve an organisation's digital transformation (Berghaus and Back, 2016; von Leipzig et al., 2017). Hence, digital maturity reveals the status quo of an organisation's digital transformation (Valdez-de-Leon, 2016). Firstly, It describes the as is situation and what has already been achieved in accordance to digital transformation efforts. Secondly, it shows how an organisation is prepared, in a systematic way, to settle and thrive in the digital ecosystem. Although it is not always clear, digital maturity surpasses the utilization of digital technologies and the reflection of information tasks and flows. On the other hand, it provides an in-depth analysis and a holistic concept of what an organisation has already achieved in term of performing digital transformation efforts. It contains changes related to products, services, processes, skills and expertise, culture and mastery capabilities of the change processes (Berghaus and Back, 2016; von Leipzig et al., 2017). As a result, firms reach the maximum level of digital maturity when they are able to have both a digital foundation and a good understanding of how to exploit this foundation as a strategic business advantage (Berghaus and Back, 2016; Mitroulis and Kitsios, 2019; Schumacher et al. 2016; von Leipzig et al., 2017; Valdez-de-Leon, 2016). The concept of digital maturity is not static. Taking into consideration the constantly changing digital landscape, firms should assess their digital maturity, strategically, more than once over the timeline of their digital transformation journey. More specifically, Valdez-de-Leon (2016) developed a digital maturity model for telecommunications service providers. In the same direction, Berghaus and Back (2016) conducted a digital maturity assessment among German and Swiss organisations suggesting that while digital affinity and experimenting with digital technology are already prevalent in firms, a strategically planned transformation and usage of advanced data analytics in business processes are less common. Most of related studies assess the digital maturity of manufacturing industry, giving less emphasis on service industries.

METHODOLOGY

Data and Variable

This research extends the use of MCDA in predicting the success factors of digital maturity in Greek small and medium service enterprises. The data collection process took place during March and May 2020. Data were gathered using a structured questionnaire, which was answered by 48 middle, senior and top-level managers who are involved in digital transformation initiatives. The questionnaire was developed based on previous surveys (Berghaus and Back, 2016; Schumacher et al. 2016; von Leipzig et al., 2017; Valdezde, 2016). As a result, 118 variables, which affect the digital maturity of an organisation, have been identified (see Table 1). These variables were deployed in the present survey. In order to measure the dependent variable that refers to the digital transformation success or failure, a five-point Likert-type scale was implemented. All variables were measured using a 5-point Likert-type scale anchored at each end with 'percentage of 0% – not done' and '100% – completely done'.

Table 1 Examined variables

Variables	Notations	Variables	Notations
Organization has a defined digital strategic vision	X ₁	Customer interaction via both traditional and digital channels	X ₆₀
Employees are aligned with the digital strategic vision	X ₂	Customer experience is consistent across all channels	X ₆₁
Clearly defined digital transformation roadmap	X ₃	Leadership team is learning new technologies	X ₆₂
High value of digital business in overall strategy	X ₄	Leaders have a compelling long-term vision	X ₆₃
Promotion and prioritization of digital product	X ₅	Leaders actively identify and realize new opportunities and foster collaboration	X ₆₄
Regarded as drivers of digital innovation in industry	X ₆	Existence of central coordination for digital transformation	X ₆₅
Clearly defined monitoring and evaluation criteria and mechanisms	X ₇	Process digitization and automation	X ₆₆
Systematic evaluation of technologies and digital innovations	X ₈	Flexibility and agility of processes	X ₆₇
Top management recognizes the importance of digital business	X ₉	Expenditure planning for communication based on media Usage	X ₆₈

Senior management takes responsibility for digital transformation	X ₁₀	Operational excellence	X ₆₉
Middle management promotes digital transformation projects	X ₁₁	Regularly check and optimise core processes	X ₇₀
Periodically review digital transformation goal:	X ₁₂	Process digitisation and re-engineering	X ₇₁
Digital transformation goals are defined measurably	X ₁₃	Digital channels integrated into communications & service processes	X ₇₂
Performance measurement	X ₁₄	Goals for digital channels determined and reviewed	X ₇₃
Digital transformation follows a defined strategic plan	X ₁₅	Digital Marketing processes	X ₇₄
Defined roles, responsibilities and decision-making processes.	X ₁₆	Ensure comprehensive and reliable execution of digital strategy	X ₇₅
Management structure supporting digital business	X ₁₇	Everyone has permission to think creatively and innovate	X ₇₆
Cross-functional collaboration	X ₁₈	Systematic approaches are implemented in innovation and change management	X ₇₇
Defined roles related to digital transformation	X ₁₉	Engagement on different hierarchical levels	X ₇₈
Adequate resource allocation	X ₂₀	Apply standards and regulations	X ₇₉
Personalized digital customer communication	X ₅₈	Suitable conditions for developing digital innovations	X ₁₁₇
Experimentation with new technologies to meet customer needs	X ₅₉	Our employees regularly contribute ideas for digital products.	X ₁₁₈

Given the classification of digital transformation efforts as success or failure, the objective of this analysis is to explore the development of a reliable digital transformation success identification/prediction model, by combining all the germane information as explained by the chosen variables. MCDA methods, which are frequently encountered in decision-making issues, are well-matched with such kind of data (Kitsios and Grigoroudis, 2020; Kitsios and Grigoroudis, 2016). Consequently, in this study, a MCDA classification methodology, named UTADIS method, is employed to implement a disaggregation approach (Zopounidis and Doumpos, 1999; Doumpos and Zopounidis, 2002; Kitsios et al., 2009; Kitsios et al., 2015). A brief description of the multicriteria methodology is provided in the next section.

Multicriteria Methodology

The UTADIS method leads to the development of an additive value function that is used to estimate the expected outcome of each digital transformation project. The developed additive function has the following general form:

$$V(\mathbf{x}_i) = \sum_{j=1}^n w_j v_j(x_{ij}) \in [0, 1]$$

where $\mathbf{x}_i = (x_{i1}, x_{i2}, \dots, x_{in})$ is the description of project i on the set of n evaluation criteria (i.e., the number of selected variables), w_j is the trade-off constant of criterion j and $v_j(\cdot)$ is the marginal value function of criterion j . The trade-off constants non-negative, they sum up to 1 and are often interpreted as proxies for the relative important of the criteria in the mode. On the other hand, the marginal value functions provide a mechanism for decomposing the aggregate result (global value) in terms of individual assessment at the criterion level. Both the global value $V(\mathbf{x}_i)$ and the marginal values are normalised in $[0, 1]$, with higher values associated with higher likelihood of success.

To avoid the estimation of both the criteria weights and the marginal value functions, it is possible to use the transformation $u_j(x_{ij}) = w_j v_j(x_{ij})$. In this way, the additive value function is simplified to the following form:

$$V(\mathbf{x}_i) = \sum_{j=1}^n u_j(x_{ij})$$

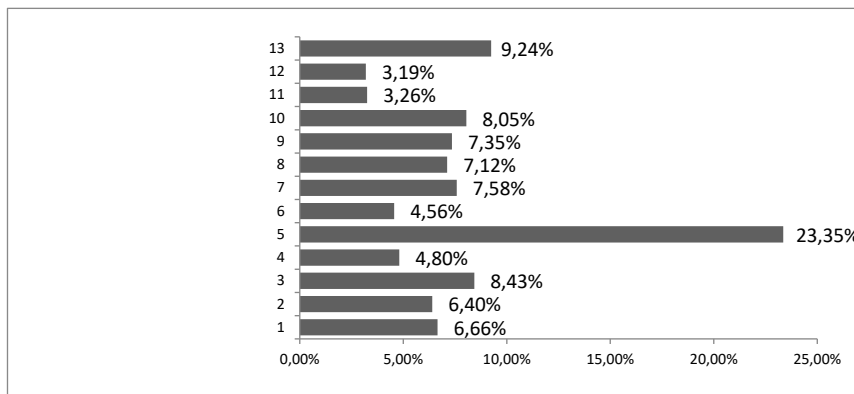
The assignment of a project i into one of the k predefined classes, is determined by comparing its global value $V(\mathbf{x}_i)$ to $k - 1$ thresholds $0 < t_1 < t_2 < \dots < t_{k-1} < 1$, that distinguish the classes. Thus, a project i is assigned to group ℓ if $t_\ell \leq V(\mathbf{x}_i) < t_{\ell-1}$.

The estimation process for the additive value function and the cut-off thresholds uses a set of data to fit the model (reference set of m projects) using linear programming (LP) techniques. The objective of the method is to develop an optimal additive model that minimises the classification error for the projects in the reference set. This is achieved through the solution of an optimisation problem which can be express in LP form. A detailed description the model and its properties can be found in the works of Zopounidis and Doumpos (1999) and Doumpos and Zopounidis (2002).

RESULTS

One of the most important results of the UTADIS method refers to the estimation of the weights of the examined factors. These weights represent the overall relative importance or the contribution of a variable in the digital transformation success/failure. The above-mentioned criteria are grouped in 13 main categories of the designed digital maturity model. Hence, the aggregation of the estimated criteria weights into 13 main categories justifies that having a concrete culture (e.g. Risk-taking, Customer-centricity, Test & learn and No-blame culture, Openness to change, etc) is the most important dimension, having an aggregate weight of 23,35%. Innovation and organisation are also important categories of variables affecting the success or failure of digital transformation initiatives, having an aggregate weight of 9,24% and 8,43%, respectively. On the other hand, cyber security and digital ecosystem seem to play a less important role.

Figure 1 Estimated importance for the main factor categories



CONCLUSIONS

The main objective of this study is to recognize and prioritize the factors of a successful digital transformation. In order to achieve this proposition, a digital maturity model has been designed focusing on a better understanding of digital transformation. The predictive model that was designed could accurately set relative weights for each one of the factors that have emerged as critical. Thus, there is an important implication that there is a correlation between having a clear digital culture and the total success or failure of the digital transformation in Greek service organisations.

The results of this research highlight the digital maturity assessment as a key determinant of digital transformation strategies in the service industry, since the digital transformation literature in the service industry is limited. The major contribution of this study is that it uses a 5-point Likert-type scale in order to measure the success or failure of a digital transformation initiative. Dealing with digital transformation is of considerable interest to both researchers and practitioners. Understanding the critical factors of digital transformation contributes to the knowledge of business transformation management which requires radical and ad hoc organisational changes. For practitioners, the results of this research might assist managers and decision-makers to prioritise their digital transformation processes and contribute to more successful digital transformation strategies. Finally, as already mentioned, this study extends other research efforts analysing the digital transformation in the service industry. Therefore, it would be very valuable to examine potential similarities or differences, regarding the presented findings.

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A multicriteria decision aid approach for measuring innovation performance

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Abstract

The assessment of countries' innovation performance is highly significant in the context of efficient policy making. The European Innovation Scoreboard (EIS) provides the Summary Innovation Index, a composite indicator for the evaluation of EU Member States' and selected third countries' research and innovation performance. Composite indicators are commonly used for the aggregation of complex or multi-dimensional processes into simplified concepts. Referring to national policies, they are frequently used for ranking countries in terms of innovation and entrepreneurship performance. However, there is controversy in regards to their credibility that mainly stems from the adopted normalization and weighting schemes. Due to these concerns, the approach of multiple criteria decision aid (MCDA) is leveraged as an alternative to construct rankings. The paper applies the PROMETHEE II (Preference Ranking Organization Method for Enrichment Evaluations) method in order to revisit the rankings of the EIS 2019 report. For each year, multiple scenarios corresponding to different values for the PROMETHEE II parameters are considered, while visual representations for the analysis of PROMETHEE II outcomes are included. Furthermore, sensitivity analysis on the criteria weights is implemented. The differences among EIS and PROMETHEE II rankings are identified and analyzed, while valuable insights for policy measures on national level are provided.

KEYWORDS

Innovation Performance; MCDA; PROMETHEE II; European Innovation Scoreboard; Composite indicators

INTRODUCTION

In the framework of policy making for the support of innovation and entrepreneurship, the measurement of innovation performance is of high importance. Composite indicators are frequently used for the assessment of countries' innovation efficiency (Grupp and Schubert, 2010). Besides their frequent use, composite indicators have been criticized (Grupp and Mogege, 2004; Munda and Nardo, 2003; Saisana and Saltelli, 2006), mainly for the weighting approaches that they follow (Becker et al., 2017).

The study focuses on a well-known composite indicator, the Summary Innovation Index (SII), presented on the European innovation Scoreboard (EIS) and is leveraged for the assessment of 37 countries' innovation performance. In the EIS report for 2019 (Hollanders, 2019), the SII includes 27 indicators which are classified in 4 main types of indicators. The first type is the framework conditions which refer to the basic drivers of innovation in regard to firm's external environment. The second type, namely, investments, identifies the level of investments made in both the business and public sector that are supportive towards the development of innovations. The third type is innovation activities, referring to various innovation aspects in the business sector. The last type, namely, impacts considers the impacts of innovation activities.

Avoiding for the fully compensatory nature of the SII, the paper adopts a MCDA approach to measure innovation performance. Specifically, the PROMETHEE II method is implemented for three subsequent years (2016-18) and the relevant rankings are constructed. In addition, sensitivity analysis on the main parameters of the model is applied. Subsequently, the corresponding findings are analyzed and concluding remarks are provided.

METHODOLOGY

The paper applies the PROMETHEE II method for each of the three subsequent years referred on the EIS 2019 report, i.e., from 2016 to 2018.

The evaluation table with the performances of the 37 alternatives (countries) on the 27 criteria (indicators) is the input of the study's approach. For cases of missing data, the paper adopts an imputation approach according to which if for criterion j the performance of alternative a or the performance of alternative b is missing no assumption is made about any preference between the two. For each of the three years, a common hierarchical weighting approach is followed, where equal weights are assigned to the four main evaluation dimensions (Appendix 1). Referring to the σ_j parameter of the Gaussian criterion, for a criterion j , the σ_j value equals to the standard deviation of all differences d_{ab} for all countries a and b on this criterion.

The study considers for two distinct sensitivity analysis approaches, i.e., sensitivity analysis on σ parameter of the Gaussian criterion and sensitivity analysis on weights. For each year, 10 scenarios corresponding to different values for the σ parameter are developed, i.e., $0.25s_j \leq \sigma_j \leq 2.5s_j$, (with step $0.25s_j$) and s_j referring to the standard deviation of all differences d_{ab} for all countries a and b on criterion j (Grigoroudis et al., 2007). Assigning low values on σ_j could lead to cases where the preference of one country over another one could be high even if their performances are similar on criterion j . By contrast, a high value on σ_j indicates that the preference of one country over another could be high only in cases where there is a significant difference in performances on criterion j . In concerns to the sensitivity analysis on weights, the study considers the weights stability intervals for the corresponding stability levels, i.e., top 20, top 10 and top 5. With stability level, referring to the pre-defined level for which the top rankings remain constant.

RESULTS AND DISCUSSION

The overall country rankings for the examined period are given in Table 1. For all three years, the top-10 of each ranking includes countries from Western and Northern Europe, while countries with lower innovation performance scores are mainly placed to Southern and Eastern Europe. In addition, the calculated positive and negative preference flows do not have high values, indicating that the differences among the innovation performances of the EIS countries are not significantly high.

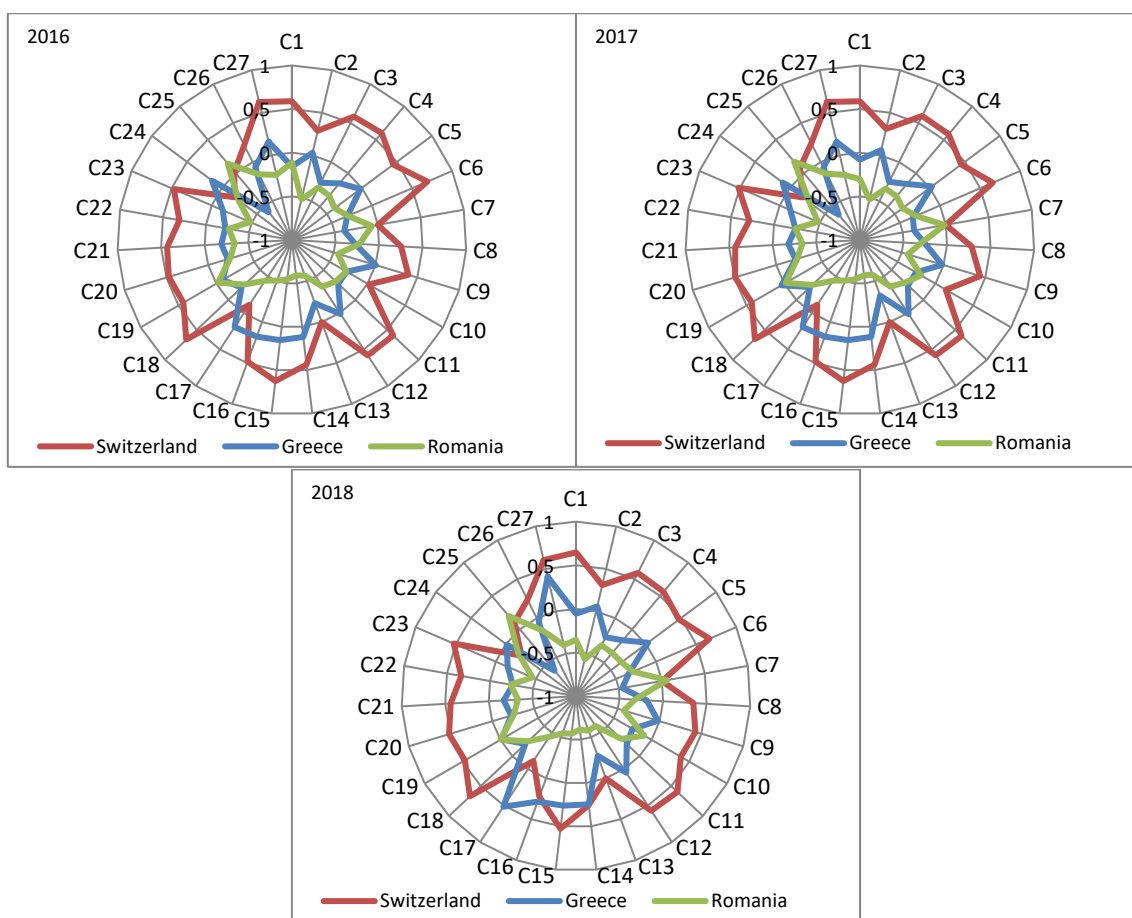
Table 1. Country rankings for 2016-2018

Country	2016	2017	2018	Country	2016	2017	2018
Switzerland	1	1	1	Spain	22	19	20
Sweden	2	2	2	Malta	20	21	21
Finland	5	5	3	Cyprus	26	24	22
Denmark	3	3	4	Slovenia	17	17	23
Netherlands	7	4	5	Italy	25	23	24
United Kingdom	6	7	6	Greece	28	27	25
Luxembourg	4	6	7	Lithuania	23	26	26
Germany	8	8	8	Slovakia	24	28	27
Belgium	11	10	9	Hungary	27	25	28
Norway	10	11	10	Latvia	30	30	29
Ireland	9	9	11	Serbia	29	29	30
Austria	12	12	12	Turkey	31	31	31
Iceland	14	14	13	Poland	32	32	32
Israel	15	15	14	Croatia	33	33	33
France	13	13	15	Bulgaria	35	35	34
EU	16	16	16	North Macedonia	34	34	35
Estonia	19	22	17	Ukraine	36	36	36
Portugal	21	20	18	Romania	37	37	37
Czechia	18	18	19				

The study provides radar charts with the unicriterion net flows for the 27 criteria, for three selected countries, i.e. Switzerland (ranked 1st for all three years), Greece (ranked 25th, 27th and 28th) and Romania (ranked 37th for all three years). Figure 1 presents the radar chart for 2018, where it can be observed that Switzerland shows high performance in the majority of criteria, while relatively weak performance is denoted in the criteria, employment in fast growing enterprises (C24), innovative SMEs collaborating with others (C17) and broadband penetration (C7). For Greece (mid-ranking country) the strongest performances are presented in innovative SMEs collaborating with others and Broadband penetration, while it presents a relatively weak performance in the majority of the rest criteria. On the other hand,

Romania's strongest feature is medium and high technology product exports (C25), while low performance is observed in all other criteria.

Figure 1. Unicriterion net flows for selected countries (2016-18)



The study considers a geographical classification of the EIS countries (besides Israel and Turkey) based on the UN European geoscheme. For each year, Table 2 provides the median preference flow and the median of ranks for all four regions. All years provide similar results, with Western Europe and Northern Europe achieving high innovation performances, Southern Europe presenting a mediocre performance and Eastern Europe having the lowest performance. These findings are compatible with the rankings of Table 1.

For the sensitivity analysis on weights (Table 3), firstly, it is observed that the criterion top-10% most cited publications (C5) has a low influence on the top-20 rankings for all three years. Similarly, for 2018 and 2017, this criterion has also a low impact on the top-10 rankings. In contrast, sales of new-to-market and new-to-firm innovations (C27) has the highest impact on the top-20 ranking for both 2018 and 2017. For 2018 in particular, trademark applications (C21) could have a significant effect on both top-10 and top-5 rankings. While for 2016, the weighting approach for the criterion private co-funding of public R&D expenditures (C19) could have a high influence on both top-20 and top-10 rankings. Moreover, for every stability level, the median for the 27 ranges of the 27 corresponding intervals is also calculated. As expected, medians with high values are observed in the top-5 rankings, with 2018 presenting the highest median among the three years.

Table 2. Median preference flow and median of ranks for the four regions of Europe

Regions	Median Phi (18)	Median Phi (17)	Median Phi (16)	Median of ranks (18)	Median of ranks (17)	Median of ranks (16)
Western Europe	0.1636	0.171	0.1596	8	8	8
Northern Europe	0.13095	0.138	0.14795	10.5	10	9.5
Southern Europe	-0.0623	-0.088	-0.0912	23	23	25
Eastern Europe	-0.1745	-0.1843	-0.1899	32.5	32.5	32.5

Table 3. Weight stability interval: The largest and smallest interval for the corresponding stability levels

	Top 20		Top 10		Top 5	
	Indicator	Interval	Indicator	Interval	Indicator	Interval
2018	C5 (2.8%)	[2.52, 7.59]	C5 (2.8%)	[2.34, 11.11]	C3 (2.8%)	[0, 36.79]
	C27 (4.2%)	[4.03, 4.27]	C21(2.8%)	[2.69, 3.2]	C21 (2.8%)	[0, 5.78]
2017	C5 (2.8%)	[1, 7.67]	C5 (2.8%)	[1, 7.67]	C14 (2.8%)	[0, 13.42]
	C27 (4.2%)	[3.63, 4.71]	C17 (2.8%)	[1.56, 3.48]	C6 (2.8%)	[1.63, 4.38]
2016	C5 (2.8%)	[0.09, 4.98]	C15 (2.8%)	[2, 7.64]	C4 (2.8%)	[0, 27.08]
	C19 (2.8%)	[2.33, 3.27]	C19 (2.8%)	[2.33, 3.27]	C20 (2.8%)	[0.69, 3.61]

The paper leverages also the Kendall's Tau correlation coefficient in order to identify the differences between the ranking for the 2.5_s scenario and the ranking for the 0.25_s scenario. For all three years, the coefficient's values are close to 1 (0.937 for 2018, 0.931 for 2017, and 0.934 for 2016), indicating that the rankings for these two extreme scenarios are considerably similar. Additionally, Switzerland and Sweden are the top-2 countries, while Ukraine and Romania have the lowest performances, for all scenarios for all three years. These findings indicate that PROMETHEE II results are quite robust in respect to the σ parameter. In the framework of comparing PROMETHEE II and EIS rankings, a strong correlation is observed for all three years, i.e., Kendall's Tau coefficient of 0.924 (2018), 0.949 (2017) and 0.922 (2016) (2-sided p value = < 2.22e-16). Table 4 presents the relevant top-10 rankings, where for 2018 the EIS and PROMETHEE top-10 rankings have all 10 countries in common, while for 2017 they have 9 out of 10 and for 2016 they have 8 out of 10.

Table 4. Comparison between PROMETHEE II and EIS rankings (top-10 rankings)

PROMETHEE II (18)	EIS (18)	PROMETHEE II (17)	EIS (17)	PROMETHEE II (16)	EIS (16)
Switzerland	Switzerland	Switzerland	Switzerland	Switzerland	Switzerland
Sweden	Sweden	Sweden	Sweden	Sweden	Sweden
Finland	Finland	Denmark	Denmark	Denmark	Denmark
Denmark	Denmark	Netherlands	Finland	Luxembourg	Finland
Netherlands	Netherlands	Finland	Netherlands	Finland	Luxembourg
U.K.	Luxembourg	Luxembourg	Luxembourg	U.K.	Netherlands
Luxembourg	Belgium	U.K.	U.K.	Netherlands	U.K.
Germany	U.K.	Germany	Germany	Germany	Germany
Belgium	Norway	Ireland	Belgium	Ireland	Austria
Norway	Germany	Belgium	Austria	Norway	Iceland

CONCLUSIONS

The paper applies a MCDA approach to evaluate the innovation performance of 37 countries based on the 27 indicators presented in the EIS. Specifically, the PROMETHEE method is applied and a hierarchical weighting scheme is adopted in accordance to the EIS' main four types of indicators.

For all three years, the top-10 countries refer to countries from Western and Northern Europe, while countries from Southern and Eastern Europe are mostly presenting low performances, indicating that geographical classification could be relevant in the assessment of innovation performance. In regards to the sensitivity analysis it is indicated that PROMETHEE II results are quite robust in respect to the σ parameter, while the corresponding rankings present similarities with the relevant EIS rankings.

Based on the paper's findings, countries could evaluate their innovation performance considering for the performances of their geographical regions or the EU's performances, and thus to reform innovation policies accordingly. The paper's basic limitation is the adoption of a single weighting approach for the criteria. Even though sensitivity analysis is implemented on weights, multiple scenarios corresponding to different weighting schemes could be considered for future research.

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Appendix 1. Weighting scheme

Conditions Framework (25%) *Human resources* (8.3%): C1. New doctorate graduates (2.8%), C2. Population completed tertiary education (2.8%), C3. Lifelong learning (2.8%). *Attractive research systems* (8.3%): C4. International scientific co-publications (2.8%), C5. Top-10% most cited publications (2.8%), C6. Foreign doctorate students (2.8%). *Innovation-friendly environment* (8.3%): C7. Broadband penetration (4.2%), C8. Opportunity-driven entrepreneurship (4.2%). **Investments (25%)** *Finance and support* (12.5%): C9. R&D expenditure in the public sector (6.3%), C10. Venture capital expenditures (6.3%). *Firm investments* (12.5%): C11. R&D expenditure in the business sector (4.2%), C12. Non-R&D innovation expenditures (4.2%), C13. Enterprises providing ICT training (4.2%). **Innovation activities (25%)** *Innovators* (8.3%): C14. SMEs introducing product or process innovations (2.8%), C15. SMEs introducing marketing or organisational innovations (2.8%), C16. SMEs innovating in-house (2.8%). *Linkages* (8.3%): C17. Innovative SMEs collaborating with others (2.8%), C18. Public-private co-publications (2.8%), C19. Private co-funding of public R&D expenditures (2.8%). *Intellectual assets* (8.3%): C20. PCT patent applications (2.8%), C21. Trademark applications (2.8%), C22. Design applications (2.8%). **Impacts (25%)** *Employment impacts* (12.5%): C23. Employment in knowledge-intensive activities (6.3%), C24. Employment in fast-growing enterprises (6.3%). *Sales impacts* (12.5%): C25. Medium and high technology product exports (4.2%), C26. Knowledge-intensive services export (4.2%), C27. Sales of new-to-market and new-to-firm innovations (4.2%).

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Exploring the Complex Dynamics of Business IT Alignment

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Abstract

Despite a considerable body of research, business IT alignment is still considered as an unachieved objective in corporate practice. Literature has identified the several factors influencing alignment, however, their inter-relationship in a time perspective has been largely under-investigated, leading to ineffective alignment actions. Based on a complex systems interpretation of the company and on a view of alignment as a co-evolution process, we propose a mathematical model that describes how alignment evolves in an organisation. The design of the model is based on 3 case studies, that provided insights on the relationship among the key factors influencing alignment. Simulation of the model shows that alignment is a complex process, where the number and type stability of the equilibrium states change according to the values of the model's parameters, and complex oscillatory regimes are possible. The alignment dynamics exhibited by the model was compared to data collected in the cases to prove, qualitatively, the model's validity. The contribution of the study is both theoretical, as the model simulation improves our understanding of the alignment process, and for practice, as the analysis of the alignment dynamics provides indications to improve the efficacy of alignment actions in organisations.

KEYWORDS

Business IT alignment, complex systems dynamics.

INTRODUCTION

Aligning business and IT resources in companies is widely acknowledged as a driver for transforming IT investments into corporate performances (Luftman et al. 2017; Cragg et al. 2002). The topic has therefore attracted the interest of practitioners and researchers for over 30 years. However, despite an extensive literature that has investigated the different factors influencing alignment, there is still a dearth of understanding of how alignment is pursued and implemented in companies (Chan and Reich 2017; Vermerris et al. 2013) and this lack results in ineffective implementation of alignment actions in organisations.

Recent research has focused on a process conceptualisation of alignment (Merali 2006; Benbya and McKelvey 2006) where alignment is seen as a sequence of actions that companies undertake to improve the consistency between business and IT. This perspective has exploited complexity science and co-evolution theory to describe the mutual influences of the different company's components in the alignment process. Studies investigated the interaction of the company's socio-technical systems (Lee et al. 2008; Amarilli et al. 2016), the influence of different factors responsible for the evolution of the alignment process (Liang et al. 2017), and the role of time (Vermerris et al. 2013). However, despite acknowledging that alignment is a complex process literature mainly addressed the topic with a linear approach, investigating the impact of independent factors on the alignment process, it described qualitatively the stages of evolution of alignment (Wang et al. 2013), and generated fragmented and partially conflicting results (Liang et al. 2017). System dynamics and simulation represent promising methodology and tools for exploring the complexity of IS evolution (Baker and Singh 2019) and have the potential to contribute to understanding how alignment occurs in companies (Peppard and Breu 2013). In the present study we address the question of how to describe through a mathematical model the evolution of alignment in companies. The study is based on an extensive literature research that highlighted the key factors influencing the alignment process and on a multiple-case study that contributed to understand the relationships among the factors. A non-linear model describing alignment is proposed, analysed, and simulated. Analysis and simulation show that the alignment dynamics and the number and type stability of the equilibrium states change according to the values of the model's parameters, and complex oscillatory regimes are also possible. Results of the simulation well fit the alignment dynamics exhibited by the companies and provides insights on actions for improving the efficacy of the alignment process. The contribution of the study is twofold. From a theoretical perspective, our research extends extant literature and improves our understanding of the alignment process and also paves the way for the application of new methodologies of investigation, based on system dynamics modelling and simulation, to the mature research domain of alignment. From a practice-oriented perspective, the study of alignment dynamics provides indications to improve the efficacy of alignment actions in companies.

THEORETICAL BACKGROUND

Since the first and ample conceptualisation proposed by Henderson and Venkatraman (1993), alignment has been the subject of investigation of several studies. Alignment literature identified and analysed an extensive set of factors, affecting the social dimension of alignment, i.e. the mutual understanding of business and IT managers, the strategic dimension, i.e. the link between business and IT strategy plans, and the operational dimension, i.e. the consistency between business infrastructure and processes and IT infrastructure and processes. Table 1 exhibits key factors and the corresponding contribution to alignment. Factors are classified as pre-conditions, enablers, inhibitors, Critical Success Factors.

Table 1. Key factors influencing alignment.

Factors	Contribution to alignment	Reference literature
Shared domain knowledge	Antecedent	Reich and Benbasat (2000); Chan et al. (2006); Vermerris et al. (2012)
Business end environment pressure	Critical Success Factor	Sabherwal and Kirs (1994); Chan et al. (2006)
Efficacy of the IT department	Enabler	Chung et al. (2003); Teo and Ang (1999)
Resources and investments in IT	Enabler	Cragg et al. (2002); Weill (1990)
Flexibility of the organisation	Antecedent	Chung et al. (2003); Vermerris et al. (2012)
Communication	Antecedent	Reich and Benbasat (2000); Vermerris et al. (2012)
Management commitment	Enabler/inhibitor	Luftman et al. (1999)
Prior IT success	Antecedent	Reich and Benbasat (2000)

Recently, alignment has been investigated as a co-evolution process (Merali 2006; Benbya and McKelvey 2006). An organisation is conceived as a socio-technical system composed of different resources, such as personnel and digital technologies, that interact and mutually adapt to improve the capacity of the organisation to react to the external business pressure posed by the competitive environment (Lee et al. 2008; Amarilli et al. 2017). Literature adopting this approach has investigated the foundations for the alignment co-evolution (Vessey and Ward 2013), the mechanisms underpinning the process (Benbya and McKelvey 2006; Amarilli et al. 2017; Peppard and Breu 2014), the principles for governing alignment inspired by other co-evolving systems (Zhang et al. 2019).

Systems dynamics is the study of the behaviour of a system through a description based on mathematical models (Baker and Singh 2019). In these models, the properties of interest of the system are treated as dependent variables and linked to influencing factors, that represent the independent variables. Links among variables can be linear, i.e. an increase in one independent variable results in a proportional increase in the dependent variables, or non-linear, where there is no proportionality between increase in independent and dependent variables. Systems composed of components that mutually influence each other and co-evolve generate feedback-loops that make the system's behaviour non-linear (Merali 2006). Non-linear models have been proposed to describe several co-evolution processes, from biology to marketing, from physics to social behaviour (Peppard and Breu 2014; Baker and Singh 2019). However, despite recognising that alignment is a co-evolution process and acknowledging the potential contribution of modelling and simulation as research tools in the IS domain (Merali 2006), alignment literature still lacks a description of the alignment process through mathematical models and computer-based simulations (Amarilli et al. 2016).

METHODOLOGY OF THE STUDY

The research methodology is based on a well-established approach in system modelling that proved to be appropriate to describe co-evolution systems (Davis, Eisenhardt, Bingham 2007). Two stages were foreseen. In the first one, the system's variables for the problem under investigation were identified through an extensive literature review. In the second stage, we conducted a multiple-case study and analysed the alignment process in three companies to select the relevant variables and gain insights into how the process is pursued. As a result, a model of alignment is proposed where key factors influence each other.

In the cases, the narratives of the alignment process were analysed with a processual approach that allowed to highlight the mutual and joint impact of the factors on alignment. Table 2 presents the three companies involved in the study and the key events of their alignment processes.

Table 2 Cases in the study.

Company	Alignment narrative
Company 1. Manufacturing company producing heating,	During a prosperous growth period, corporate IS was deeply customised. Leadership position and growing market hid the limitations of the IS and

cooling, and renewable energy technology. One main production plant. Network of outsourcers for cooling systems, mainly national. Network of dealers.
Size: 60 million € in 2017
Interviews: 10 interviews with C-level managers in 2017-2018.

Company 2. Manufacturing company producing machinery for pasta. One production plant and suppliers for components and assembly. Sales through though direct contact with customers.
Size: 90 million € in 2018.
Interviews: 8 with C-levels in 2018.

Company 3. Manufacturing firm producing spray packaging solutions and filling equipment. Group with 9 legal entities and 12 production plants. Size: 200 million € in 2018.
Interviews: 12 with C-level managers in 2019.

reinforced a reactive mentality of the personnel, including IT department. In 2005, the limitations of the existing IS became evident and management pressed for IS renovation. The IT department was re-organized (new CIO and IT governance) and its efficacy in seizing needs and finding solutions significantly improved. The application portfolio was revised towards modularity and flexibility. IS capacity to match emerging business needs benefitted from the transformation, however alignment process was hindered by lack of funds allocated by the top management to IT and by the rigid mentality of personnel negatively reacting to introduction of new software.

Company has grown significantly in the national market of machinery for pasta. Leading position hindered investments in IS that was gradually customised and become outdated. When competitive environment changed and new agile competitors appeared, the company faced the inflexibility and inability of its IS in supporting manufacturing processes that require agility. The company undertook an ambitious renovation project, corporate IS was redesigned and internal processes redefined accordingly. Open mentality of personnel, used to work on a project base, helped introduce and exploit the novel IS.

Company operates in a stable market. Key success factor for company's growth was automation at production level, which was not reflected in the development of the IS, outdated, inflexible, expensive. No IT governance mechanisms were introduced to govern users demand and IS planning. Relevant organisational events led to replacement of prominent figures in the company and to re-organisation of the IT department. A process of re-organisation of the whole company and of revision of the IS was initiated.

To trade off realism against analytical tractability, the alignment model proposed in the study is minimal, as it incorporates one independent (state) variable to describe alignment and a limited number of variables representing the factors influencing the alignment process. The proposed alignment model is in discrete time, as we witnessed that companies do not undertake alignment actions continuously through the year, but in specific events, such as IT budget formulation (once per year) or periodic end users' needs analysis.

RESULTS: A MODEL FOR DESCRIBING BUSINESS IT ALIGNMENT

Alignment is pursued through the action of the IT department in its capacity to identify needs and to transform them into revisions of the corporate Information System (IS). The efficacy of this action is moderated by the capacity of the organisation to embrace and exploit change. Finally, alignment is influenced by the dynamicity of the environment, as a quickly changing competitive environment or technology obsolescence can contribute to make the IS outdated and unable to match business needs. The model formulation and its main stocks are presented and commented below.

$$x(t + 1) = x(t) + A(x(t)) - B(x(t))C(x(t))$$

Employees' satisfaction with IT is considered as a proxy of alignment and chosen as state variable. $x(t)$ represents the percentage of end users dissatisfied and complain about IT with the IT department.

$A(x(t))$ represents the effect of the environment on alignment and takes into account two aspects, the dynamicity of the competitive environment, that poses new business challenges that require intervention on the IS, and the technology obsolescence, that makes the IS quickly outdated. In Company 2, for instance, a rising competition by small and agile manufacturers pushed the company to revise its IS in order to help reduce products delivery time. In Company 1 and Company 3, obsolescence of the ERP system caused inefficiencies in several corporate processes and reduced competitiveness of the company.

$B(x(t))$ represents the capacity of the IT department to understand business needs and transform them into IT projects. This capacity is influenced by the capacity of the department to intercept needs, the flexibility of the IS, and the availability of financial resources to fund IT projects. During the renovation process of the ERP system, Company 3 defined IT governance procedures, including demand analysis, that were efficacious in focusing on few ERP functionalities that matched end users' requirements. In Company 1, reduction of funds for the IT department, due to lack of trust of the top management on IT, hindered the renovation project.

$C(x(t))$ represents the capacity of the organisation to effectively exploit IT and adapt to it. This stock is connected to the sensitivity of the company to the need of change and to the capacity of the organisation to quickly adapt to new technological solutions. In Company 2, the open-minded mentality of the personnel, used to work on a project base, together with flexible procedures eased the adoption of a new IS. In Company 3, pressure posed by the top management

improved sensitivity of the end users to adopt new technologies. The detailed formulation of the model and the key variables influencing alignment are presented in Table 3.

Table 3 Alignment model.

Model stock and variables	Key factors
$x(t)$ $A(x(t)) = d(1 - x(t))$ $B(x(t)) = \frac{ax(t)(1 - x(t))^g}{1 + ahx(t)}$	Percentage of dissatisfied end users d : dynamicity of the environment a : efficacy of the IT department to understand business needs h : flexibility of the IS to be adapted g : IT investment propensity
$C(x(t)) = \frac{((1 - r)x(t))((1 - r)x(t))^s}{((1 - r)x(t))^s + (r(1 - x(t)))^s}$	r : activation threshold s : organisational flexibility

The number and type stability of the equilibrium states were numerically studied, and the dynamics of alignment was simulated under different combinations of factors that represent typical scenarios, such as high efficacy of the IT department, inflexible IS, IT investment policies, reactivity of the organisation to accept change. The alignment dynamics exhibited by the model's simulation was compared to that of the cases.

An effective IT department raises alignment. Alignment improves if the capacity of the IT department to understand needs (a) and of the IS to be transformed (h) grow. Improvement does not proceed linearly with business needs and a saturation effect occurs, caused by the decreasing capacity of the IT to address all requests. In Company 1 and Company 3, for instance, the introduction of new profiles in the IT department dedicated to demand management and the replacement of the legacy system with modern, modular system contributed positively to alignment. However, in the latter case, as the number of business requests increased, the IT department capacity to respond was hindered by the lack of resources.

The role of the investment policy is critical. An increase in the fraction of company's resources dedicated to IT (g) improved alignment in all cases. The study of the stability of the equilibrium suggests that beyond a certain value of g , i.e. in a condition when the management remarkably reduces the investments in IT, the unique equilibrium point of the system becomes a condition of full misalignment. This dynamics was reported by Company 3, where continuous reduction in IT resources in a condition of increasing competition generated a point of no return, leading to full dissatisfaction. Only replacement of the top management and reorganisation of the IT department created the conditions for re-aligning IT and business.

The dynamics of alignment is complex. The complex and non-linear nature of the model shows possible cyclical regimes. In Company 1 and Company 2, combination of highly competitive environment, revision of the IT investment policies and IT governance, enhanced capacity of the IT department to detect needs, and IT pressure on organisational flexibility determined an oscillatory dynamics of alignment where periods of satisfaction were alternated with periods of dissatisfaction with IT.

DISCUSSION AND CONCLUSION

In this study we propose a minimal model to describe how alignment is pursued by companies. Despite its simplicity, the model well captures the dynamics of alignment in a real environment. The contribution of the study is both for theory and for practice. From a theoretical perspective, the simulation of the model contributes to understanding alignment dynamics not predictable with qualitative studies, paving also the way to the application to a mature area of research, such as alignment, of novel methodologies of investigation based on system dynamics. From a practice-oriented perspective, the analysis of the alignment dynamics provides suggestions on how to improve and manage alignment implementation in companies.

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An Exploratory analysis of the use of ICT by Greek households through official statistics

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Abstract

The use of technology by households has undoubtedly increased significantly in recent years. The advancement of technology itself is an important factor influencing the use of technology goods for either consumer or capital purposes. There are, nevertheless, additional factors that can change the behavior of technology users, including economic, political and social developments. Economic transformation and e-commerce, public sector administrative and digital reforms, the evolution of forms of communication but also emergency situations such as natural disasters and disease management play an important role in how people use technology. The aim of this paper is to present an exploratory analysis of how individuals used information and communication technologies through official statistics such those compiled by the Hellenic Statistical Authority (ELSTAT) between 2017-2018. Our work highlights the prevailing trends and groups of users which took place at a time where the Greek state accelerated administrative reforms aimed to electronic services.

KEYWORDS

Official Statistics, Exploratory statistics, Hierarchical Clustering, Information and Communication Technologies, Households

INTRODUCTION

In recent years, there have been particularly significant developments in the field of Information and Communication Technologies (ICT). The widespread use of smartphones and other IoT devices, the improvement of internet accessibility, the extensive use of cloud computing infrastructures, the enhancement of computer systems security, new forms of electronic payments, e-commerce, the use of ICT at work, e-governance and social media boom form the context of household use of ICT. It has been well stated that Information and Communication Technology (ICT) investments are the driving force behind the resurgence of growth in the developed countries (Europe-Greece)(Antonopoulos and Sakellaris, 2009) (At the same time, the adoption of ICT by households is not only associated with sustainable development (Hilty & Hercheui, 2010) but also with emergencies such as natural disasters and epidemics (i.e covid-19) that set a need that has to be satisfied. The use and adoption of ICT by households is influenced by factors that have been scientifically recorded. These factors are divided into 4 categories: economic, technological, social and organizational (Ziemba E, 2016). More specifically, the economic factors include those characteristics that concern the financial situation of households, the cost of acquisition and the existing funding for the acquisition of ICT by the state. (Leng, Ma, Tang & Zhu, 2020). Technological factors are related to features such as devices, computer infrastructure, security systems and digital skills. Continuing, social factors are associated with characteristics that include the use of social networks, technological fear and various demographic characteristics of households (e.g. age, education , employment status etc.) (Hernández-Encuentra, E. et .al 2009). Finally, in the organization factors we can find characteristics related to the satisfaction from the use of ICT. Creating user groups based on the age feature lays a substantial basis on which a more extensive study can be based. The qualitative base includes the specific characteristics of each user group on which the Greek state can intervene and implement a personalized digital policy aimed at, for example, digital convergence with countries that are more digitally advanced.

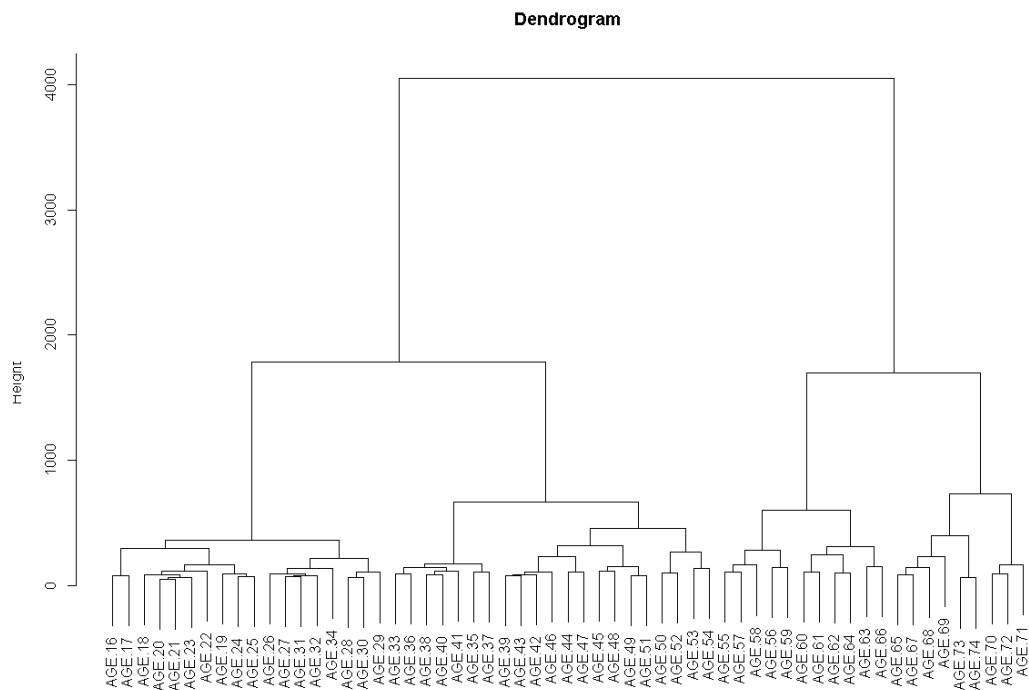
METHODOLOGY

The methodology followed for our research was based on official statistics as collected by the Hellenic Statistical Authority during period April 2017 – March 2018. For this reason, a specially designed questionnaire was designed to collect responses of ICT usage from Greek households. The questionnaire was answered by 5205 people. In order to perform our study we used automatic clustering and specifically the agglomerative hierarchical clustering (HAC) or else called ascending hierarchical classification (CAH). On this method the objects are joined in pairs based on a criterion based on their distance. The clustering algorithm is completed when all the original objects are merged into one. The scientific interest in grouping new data types, such as mixed data types, etc., remains undiminished (Moschidis O., 2015), (Moschidis O., Chadjipadelis T., 2017), (Angelos Markos, Odysseas Moschidis, Theodore Chadjipantelis, 2020) The questionnaire is divided into following sections: Demographic elements of the respondent, access to selected information and communication technologies, internet usage, use of e-governance, use of e-commerce, trust-security-protection of personal data, the use of information and communication technologies at work, digital skills.

RESULTS

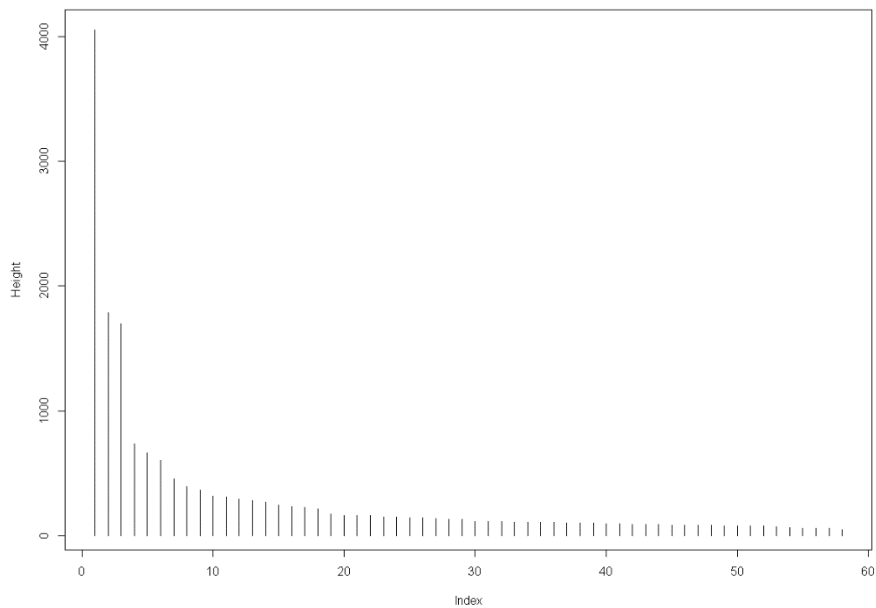
We used R programming language to perform all needed data preparation and analysis (libraries: (Agnes and Factominer). Next we will show the results of the clustering based on the common presentation of a clustering procedure that is a) the construction of the clustering tree, b) pruning the hierarchical tree and c) characterize the clusters according to their important

Figure 1. Dendrogram



In order to decide how many groups should we keep, we have to check the so called “Height barplot”.

Figure 2 Barplot of the heights as a help to choose the number of clusters



According to the above diagram a good grouping would be to maintain the last 3 groups which from the height barplot seem to correspond to the ages 16-34, 35-54 and > 54. But an equally good grouping that could specialize subcategories of the above age groups would be to maintain the last 6 groups and this corresponds to the age groups 16-25, 26-34, 35-40, 41-54, 55-65, 66-74.

To see what were the most important characteristics of each group we performed v-tests to see if the mean of a characteristic in a group was significantly different from the mean of the characteristic in all individuals. Therefore any value of the bilateral control greater than 1.96 indicates statistical significance of the attribute in the group (positive contribution). To show even more important points we got these with a value of $v.test > 3$.

Table 1. Important attributes of Cluster (group) 1

Attribute Name	v.test	Mean in category	Overall mean	sd in category	Overall sd	p.value
EMPST.3	4,774038	15,05556	4,677966	15,46491	10,96905	1,81E-06
IUPDG.1	4,16174	22,16667	15,35593	6,726812	8,258047	3,16E-05
IGOV12RTX_NAP.1	3,907164	8,444444	3,627119	9,447058	6,221609	9,34E-05
EMPST_OTH.3	3,406801	0,5	0,152542	0,833333	0,514652	0,000657
BELRN.1	3,323804	1	0,440678	1,20185	0,849151	0,000888
IUP2P_ACCO.1	3,156895	1,722222	1,016949	1,095727	1,127342	0,001595

According to the table above the most important characteristics of the age group 16-25 are: Their employment status is pupil / student or non-financially active (soldiers), during their personal use of the internet they played or downloaded games, did not send completed forms online as they did not have to submit any official form, ordered e-learning material through the internet and used apps like Facebook, Instagram to find accommodation from another individual for personal use. The population of this group is 363 individuals.

Table 2 Important attributes of Cluster (group) 2

Attribute Name	v.test	Mean in category	Overall mean	sd in category	Overall sd	p.value
BCLOT.1	4,434475	30	15,33898	4,869732	9,238112	9,23E-06
ISCEDD.4	4,362959	10,14286	4,40678	2,948538	3,673629	1,28E-05
IBUY.1	4,351033	41,42857	22,32203	5,900536	12,27018	1,35E-05
BOTA.0	4,32044	37,57143	20,32203	4,71645	11,15597	1,56E-05
BOTHTH.0	4,306747	42,71429	23,40678	5,091008	12,52674	1,66E-05
BBOOKNL.0	4,178858	40,71429	22,62712	3,989783	12,09412	2,93E-05
BFDOM.1	4,127917	41,14286	22,9661	5,30306	12,30401	3,66E-05
BFUNK.0	4,115297	45,85714	25,50847	6,334228	13,81644	3,87E-05
BELRN.0	4,104031	46,42857	26,0339	6,673126	13,88569	4,06E-05
...

According to the table above the most important characteristics of the age group 26-34 are: Buy clothes from the internet, the level of education completed is Public or Private Vocational Training Institute (IEK, IIEK), college lasting up to two years or Master / Postgraduate, do not buy travel services such as car rental tickets, etc., do not buy books or magazines or newspapers in electronic form, buy more than non-domestic sellers, buy.

Respectively we receive information about the other groups.

Group 3 with a population of 525 people is characterized, more importantly, by the following: these are people who have graduated from higher education and work as employees with permanent or indefinite work. These people often visit the internet mainly from their smart phone, they do not buy cloud services, they do not interact electronically with the public sector but only through their representatives, although they do not find any problem in the electronic infrastructure offered to them. From e-commerce they prefer to buy household items and use simple identification with username and password as a measure of security of their data and nothing more even though they have suffered damage to their data due to malware. The group of people also states that it has not carried out any educational activity to improve its digital skills.

The 4th group with a population of 1401 individuals is characterized, more importantly, by the following: They are housewives from the Aegean islands and Crete who did not send completed forms etc. when communicating / trading with public services and authorities via the internet due to lack of knowledge. These individuals consider age to be a risk factor for exclusion from electronic / technological integration. These people used the internet at least once a week but not every day and do not use smartphones. They do not use any electronic identification process when browsing the internet even though they have participated in social networking sites. They do not use the internet for entertainment and did not send or receive emails over the internet.

The 5th group is characterized most strongly by: are retired housewives living in rural areas with the lowest level of education who believe that level of education, occupation and age are risk factors for exclusion from electronic / technological integration. This group did not use the internet during the period covered by the survey.

The 6th group is characterized most strongly by: non-use of internet during the research period. They consider that age is a factor that strengthens the technological exclusion, they have only completed primary education, they are retired women and they live in non-urban areas of Attica.

CONCLUSIONS

The application of the hierarchical clustering method highlighted 6 age groups of ICT technology users. The first age group as expected uses ICT technologies mainly for entertainment reasons. It is also not significantly characterized by their demographics. The second age group is characterized by moderate to highly educated people, who make significant use of e-commerce with their main suppliers located in the European Union. The third group consists of people from the "labor market". The use of ICT technologies is more intense than the other groups, the interaction with the public sector takes place mainly through representatives and the lack of retraining in digital skills is important as the existing ones are considered satisfactory. In the 4th age group prevails the profile of women from the Aegean islands

and Crete who use the internet in order to receive information but also to communicate on social networks. It is possible that the fear found in the lack of knowledge limit their further involvement with ICT products and services. Regarding the 2 older groups, we observe that there is very little or no use of ICT technologies. This is justified by the low incentive that these individuals may have, but at the level of digital policy, steps must be taken to enable these groups to acquire a set of skills that will allow them to perform some of their electronic duties independently One final note is that demographics do not play a significant role in the adoption of ICT technologies. However, the technological fear that is created in the groups, especially older ones, is considered important and must be retreated. Therefore a practical contribution our study can be used by policy makers to understand better the peculiarities of age clusters of Greek ICT users while making decisions for digital transformation strategies.

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Verification of Academic Qualifications through Ethereum Blockchain: An Introduction to VerDe

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Abstract

Blockchain technology significantly contributes to the verification process of academic qualifications since, by design, is resistant to modification of the data it holds. Blockchain is an open, distributed ledger that can record transactions of a community efficiently and in a verifiable and permanent way. In the context of academic qualifications, it can be assumed that: (a) an academic qualification is a public transaction between an Institution and an individual, (b) some stakeholders need to access these transactions, and, (c) each transaction cannot be modified once executed. These assumptions in conjunction with the decentralized nature of blockchain and the nonnecessity of a trusted authority make blockchain an attractive solution. This paper presents the conceptual design of *VerDe*, an application that aims to verify academic qualifications exploiting the Ethereum Blockchain. Similar applications have been proposed in literature but appear to have high implementation and maintenance costs. *VerDe* is innovative in utilizing cryptocurrencies, namely the ERC20 token, for the verification of academic qualifications. The advantages of the proposed approach are: (i) integrity of stored data, (ii) decentralized data storage, (iii) instantaneous verification, (iv) low development and maintenance cost, and, (v) user-friendly interface. The paper discusses the potential benefits of *VerDe* through two use cases: for fraud detection and study mobility.

KEYWORDS

Ethereum Blockchain, ERC20 token, Smart contracts, Verification, Fraud detection

INTRODUCTION

Education is an important pillar of modern societies. Nowadays, mobility, due to educational and/or professional reasons, is a global trend since more and more people study and work in different countries/cities worldwide. This trend provides a financial uplift to countries and is even encouraged through International and European projects like Erasmus+. According to UNESCO data, international student mobility in tertiary education increased as much as 25,5 % from 2013 to 2017⁵.

Such extended mobility has increased the necessity of verification of academic and/or professional qualifications for potential applicants and current job-holders; especially to detect and avoid fraud in critical employment positions, e.g., medical doctors. For example, press reveals incidents of people holding and submitting fake academic degrees; among others, indicative is the case of big industry in the Philippines that provided forge diplomas⁶. The traditional defense against fake diplomas is stringent verification procedures. Some countries cope with this issue with government bodies, such as the Academic Degrees and Graduate Education Development Center in China, the Hellenic N.A.R.I.C (National Recognition and Information Center) for verification and recognition of foreign diplomas. In some other countries, accreditation is supervised by non-government bodies, such as the Council for Higher Education Accreditation (CHEA) in the USA. However, most credential verification mechanisms are old-fashioned, time-consuming, financially expensive, and incompatible with the pace and needs of modern society. Thus, a global verification system to validate academic qualifications by reducing the bureaucracy and communication requirements between Universities is a necessity.

In the context of academic qualifications, it can be assumed that: (a) an academic qualification is a public transaction between an Institution and an individual, (b) some stakeholders need to access these transactions, and, (c) each transaction cannot be modified once executed. These assumptions in conjunction with the decentralized nature of blockchain and the nonnecessity of a trusted authority make blockchain an ideal solution. Blockchain technology can significantly contribute to the verification process of academic qualifications since, by design, is resistant to modification of the data it holds. Blockchain is an open, distributed ledger that can record transactions of a community efficiently

⁵ Source: <http://data.uis.unesco.org/#>

⁶ Source: <https://www.bbc.com/news/av/health-32791195/philippines-booming-qualification-forgery-industry>

and in a verifiable and permanent way. This paper presents the conceptual design of *VerDe*, an application that aims to verify academic qualifications exploiting the Ethereum Blockchain.

Similar applications have been proposed in recent literature. The first application for the verification of academic qualifications was created in 2015 by the University of Nicosia (UNIC) [Karasavvas] and uses Bitcoin. It hashes diplomas into a Merkle root, sends it to Bitcoin, and then it records the Transaction ID to diploma's metadata. An individual has to upload his/her diploma to their platform to verify it. UZHBC [Gresch] is a solution proposed by the University of Zurich. It uses Ethereum blockchain and has a similar verification process with the UNIC. Individuals upload their diplomas on a platform and then hash and store the output on contract state and blockchain. Turkannovik et al. [Turkannovik] proposed in 2018 the EduCTX platform with the vision to become a worldwide certification network of academic units. A major requirement of the platform is that the academic unit themselves should constitute the nodes of the blockchain. EduCTX was developed on the Ark blockchain and requires that each University has to own the appropriate infrastructure (e.g., servers) in order to participate in the network; however, this approach entails high implementation and maintenance costs. In addition, it introduced a custom token, i.e., the ECTX token, and the verification is taken place by presenting the possession of ECTX. This customized token is different than the ECTS units which are the traditional scheme used by Universities to assign credits to students each time they succeed in exams.

Along these lines, we present the decentralized web application *VerDe* (*Verified Degrees*) which is based on blockchain technology and smart contracts to provide verification on the validity of a diploma. The innovation of the application lies in the fact that it uses Ethereum blockchain for verification and exploiting cryptocurrencies, namely the ERC20 token, for the verification of academic qualifications. The advantages of the proposed application are: (i) data integrity, (ii) decentralised data storage, (iii) instantaneous verification, (iv) low development and maintenance costs (no need for special equipment), and (v) user-friendly interface. The paper briefly presents the blockchain technology and smart contracts, provides design details regarding the *VerDe* application, and discusses the potential benefits of *VerDe* through two use cases: for fraud detection and for study mobility.

BLOCKCHAIN TECHNOLOGY AND ETHEREUM SMART CONTRACTS

In 2008 the idea for the first blockchain was launched with the creation of Bitcoin by Satoshi Nakamoto [Antonopoulos]. This idea is also the solution to the Byzantine Generals Problem [Antonopoulos]. Drescher [Drescher] defined blockchain as: *“a purely distributed peer-to-peer system of ledgers that utilizes a software unit that consists of an algorithm, which negotiates the informational content of ordered and connected blocks of data together with cryptographic and security technologies in order to achieve and maintain its integrity”*.

Bitcoin was the first blockchain but not the last. Ethereum blockchain was inspired by Bitcoin and was proposed in 2014 by Vitalik and Gavin Wood [Wood]. It uses the Proof of Work, it is a permissionless blockchain and it is essentially a transaction-based state machine. Ethereum blockchain uses endpoints and works with JSON-RPC API which is supported by Ethereum Web3 API, that is, from the web3.js library [Wood]. It has the same goal as the Bitcoin, the integrity of data. Ethereum's architecture is the same on the core with the Bitcoin but quite different on the implementation, with many extra components. The 4 main components of Ethereum are [Wood]: **(i)** the Accounts, consist of Externally Owned Accounts (EOAs), which are users' wallet, and the Contract Account that contains the smart contract's code, **(ii)** the World State, it is a mapping between addresses (160-bit) and account states to store transactions, **(iii)** the Block which includes all block components of Bitcoin and many more, because it has more functionalities, and **(iv)** Transactions which are what make the World State change from one state to other. There are 3 types of transactions a) transfer values between EOAs, b) to send a message call to a smart contract, and c) deploy a smart contract.

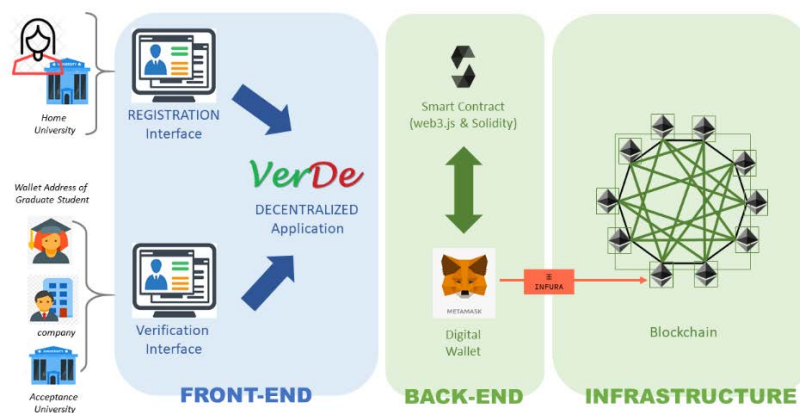
The most important feature of Ethereum is the Ethereum Virtual Machine (EVM) [Wood] which executes and processes smart contracts. Its purpose is to update the World State of Ethereum by calculating valid transitions as a result of the execution of Smart Contracts [Wood]. The best-known high-level programming language for smart contracts is Solidity [Wood]. This is a “contract” oriented programming language and it is almost the same with the object-oriented programming languages. A smart contract is a collection of code (its functions) and data (its state) that resides at a specific address on the Ethereum blockchain. It is a Turing complete programming language. This has the disadvantage of endless loops and could create a serious problem in the Ethereum network. However, the creation of infinite loops is not possible because Ethereum uses a limit defined as Gas and accumulates the cost of transactions that decrease the sender's funds each time he executes a transaction. The limit on gas consumption during the development of a smart contract can also be seen in the diagrams of the Tonelli et al study [Tonelli]. In this survey, 12,094 smart contracts were studied and compared on general metrics and metrics for decentralized applications only. In all the above metrics it seems to reach an upper limit and this is due to the limitation of the gas that can be consumed by smart contracts. The smart contract is a rather important part of decentralized applications as it acts as the database for these applications. All data stored in a contract is stored on the contract state. It is also compiled at the low level in bytecode

with the help of EVM. Finally, a highly important function that smart contracts carry out is that of sending and storing cryptocurrencies.

VERDE CONCEPT

In this section, we elaborate on design details regarding the architecture of our decentralized application *VerDe* which aims to verify academic degrees based on blockchain technology and smart contracts. Our application exploits the Ethereum blockchain and consists of three main components: (i) the presentation component, (ii) the control component, and (iii) the communication with the blockchain component. The first component provides the user-interface (Fig. 1, Front-end, blue area) and gets the input data; the third one is based on the web3.js library and communicates with Ethereum's blockchain (Fig. 1, back-end, green area). The control component combines the previous two and acts as the "brain" of the application [Zinca].

Figure 1. An abstract view of the VerDe architecture



As depicted in Fig. 1, the application's front-end is further divided into 2 interfaces: (1) the Registration interface which sends users' data, e.g., name, birth date, department, courses, evaluation scores, to the Ethereum, and (2) the Verification interface that verifies users' data stored to the blockchain. We design two interfaces in order to isolate the registration process, which is an internal procedure being supervised by the Academic units themselves for their own students exclusively, from the verification process, which is a public procedure accessible to any interesting part, e.g., other Universities, companies or individuals. The connection between the front-end and the back-end is achieved through the web3.js library, which is installed on the interfaces and it is part of the back-end and the smart contract (Fig. 1 back-end). The functionality of the application and the property of decentralization is achieved through the smart contract. Access to the blockchain requires: (i) a digital wallet and (ii) a connection to a full node. The digital wallet includes the user's funds and calculates the cost of a transaction (that will be removed from his wallet if he accepts it), while the full node is getting informed for the new blockchain blocks and creates new ones. The communication between the digital wallet and the full node is accomplished by the MetaMask, which is also part of the back-end of the *VerDe* application. MetaMask was developed by ConsenSys and is an online application (browser extension) of a digital wallet. Furthermore, the connection to the nodes of the Ethereum network is done through the Infura application, which runs on the back-end of MetaMask.

VerDe uses Ethereum blockchain which is the second-largest blockchain network at the moment in terms of market value (14,5 Billion dollars during February 2019), the number of nodes, and frequency of transactions and it is public (permissionless) [Ningyu]. Individual's data, e.g., post-graduate student, sent to the public Ethereum blockchain encrypted, in accordance with the GDPR guidelines, and using his/her wallet address. Based on this unique wallet address, a third party (independent from the host University and the individual) looks for the student's diploma, receives its related-date encrypted, and then proceeds with the decryption and verification. This entails that the verification process can be repeated multiple times, without the intervention of the host Institution.

Regarding the smart contract, *VerDe* uses the publicly available ERC20 token⁷. Its operation is based on the creation of a large number of tokens, owned and managed by the one who developed the smart contract and operates as a common

⁷ Source: <https://en.bitcoinwiki.org/wiki/ERC20>

cryptocurrency. These tokens represent the ECTS that student gathered from courses. These are created once and can be minted by the unit in case of running out of tokens but, neither can be reproduced or transferred without the owner's approval, nor between students. All token transactions are linked with the address of the contract, i.e. the list of transactions made with this token is displayed at the contract address at the website of transactions of the blockchain (Etherscan). Thus, it is possible to verify the transaction between the sender's address and the recipient, i.e. there is transparency in transactions. Finally, the number of tokens send and stored each time to the recipient/student's wallet is removed from the sender's balance.

VerDe application aims to bridge the gap of current applications that use either verification by presenting information or token verification. The unique existence of showing student's data in order to verify a diploma confronts some problems: a) possibility that the verification interface could be compromised, b) university corruption (a unit may send fake information on purpose), c) single point of failure and d) an interface is required. Furthermore, the unique existence of tokens, in order to verify a diploma also, encounter some problems: i) insufficient verification details, ii) non-user-friendly and iii) wallet requirement to be verified. VerDe implements both verifications since they complement each other. In addition, applications like EduCTX, which executes only token verification, have high management cost as they require both students and academic units to maintain verification keys on EduCTX blockchain. Moreover, uploading a PDF to a platform in order to verify it and present user data (UZHBC and UNIC) does not provide a reliable solution to the problem of verifying academic degrees. Besides, our solution of smart contracts can be modified (i.e. with another deploy on Ethereum) to achieve a second solution for another problem that occurs in a university (e.g. employers list and bonuses). Design choices of *VerDe* promise a reliable, instantaneous, two-way verification, low cost, and user-friendly application.

USE CASES

In this section, we discuss the benefits of *VerDe* through two use cases: (i) the fraud detection case, and (ii) the study mobility case. *VerDe* is an ideal technological solution in both cases.

Every country across the world considers forgery diploma as an illegal action. The case of a doctor with fake qualifications who worked as an NHS consultant psychiatrist for 22 years was announced in 2018⁸; this is a local example, but similar issues occur worldwide. Nowadays, such an incident would be easily prevented using *VerDe* application and without bureaucracy barriers. On the contrary, *VerDe* can provide an easy to use, fast and repeated verification which is due to the blockchain is valid and legit. Let us suppose that a medical graduate wants to work abroad and submits many applications worldwide. His/her host University has the option to store all studies-related information in Ethereum blockchain (e.g., name, birth date, classes, specialization, evaluation) through the *VerDe* application. In case that the graduate submits for an anesthesiologist position while he/she holds the specialization of ophthalmology, the verification process will detect the fraud attempt and any recruitment will be frozen. Consequently, any third unit can be assured that candidate employees and their skills are valid.

Even more interesting is the mobility for an educational reason to foreign countries or continents. Traditional approaches require that every country must have an accreditation body to verify foreign diplomas or qualifications. In the Frequently Asked Questions (FAQ) of N.A.R.I.C describes that a period of 3 to 5 months is required to validate a foreign diploma. This is a highly time-consuming process and unappealing to many students. On average a student applies to more than one university or company and he/she has to verify his/her diploma to each one. As a result, stakeholders must have fast and valid verification processes. *VerDe* is an application that can be used in such situations and fulfills the requirements for reliability, low delay, easiness, and repetition. Our solution can verify graduates' diplomas in a couple of seconds, multiple times and without any cost, bureaucracy, or further requirements for the host unit.

CONCLUSION AND FUTURE WORK

The proposed application is a state-of-the-art approach because it has a two-way verification system and it is easy to use, instead of other solutions that have only one of them. Also, a smart contract does not need equipment to execute them to the Ethereum blockchain. *VerDe* is a complete solution with properties such as strong validation, inexpensive

⁸ Source: <https://www.theguardian.com/uk-news/2018/nov/19/thousands-of-doctors-under-scrutiny-after-fake-qualifications-case>

deployment, fast verification, and publicly accessible; moreover, there is no need for a user to hold a specific file to verify his diploma. Our next goal is to develop VerDe's interfaces and its smart contract. It is certain that in the future the security services provided by blockchain technology will make a significant contribution to the electronic services of the private and public body.

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Essential Digital Technologies for Achieving Digital Maturity in the Fashion Industry

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Abstract

Organizations try to integrate digital elements into every aspect of their business to enhance their digital presence and operations. The majority of the organizations invest in a variety of digital technologies to improve the offered customer experience, business operations, and business model. Digital strategy sets the directions for which investments should be made and how digital technologies are going to be used during this digital transformation. Thus, digital technologies investments and integration are equally important parts of digital transformation. Investments in digital technologies have been made in every industry; however, the fashion retail industry was among the first industries that started a digital transformation process by investing in digital technologies and responding to changing customer preferences in order to improve experience. The most common technologies that have been used in fashion retailing are Social, Mobile, Cloud, Artificial Intelligence, Internet of Things, Virtual Reality, Big Data, and lately blockchain. We choose to focus on the fashion retail industry because digital technologies have caused significant changes in it. This research aims to be an introductory theoretical approach, focusing on 3 essential digital technologies (Artificial Intelligence, Blockchain, Internet of Things) that have been used or are going to be used for industry's digital transformation. We summarize their main applications and impact in customer experience and operations; to help organizations and managers select more suitable technologies according to their digital strategy during digital transformation and prevent misplaced investments. During digital transformation, financial resources are an important parameter that determines the number of changes that can be occurred in the organization and the number of investments. Thus, our research will help organizations invest in rising and relevant digital technologies for the fashion retail industry.

KEYWORDS

Digital Transformation, Digital Technologies, Mobile, Artificial Intelligence, Internet of Things

INTRODUCTION

In a recent work Vial, (2019) defines digital transformation as “a process that aims to improve an entity by triggering significant change to its properties through combinations of information, computing, communication, and connectivity technologies”. On the other hand, Matt, Hess, & Benlian, (2015) list the elements that influence organization's strategy regarding digital transformation; these elements include the use of technologies, changes in value creation, structural changes, and financial aspects. Both cases, underline the importance of digital technologies in the digital transformation process as organizations implement digital elements in every aspect of the organization, according to their digital strategy. Consequently, digital strategy not only sets the pace and speed of digital transformation (Vial, 2019) but also determines the digital technologies investments.

Digital technologies are a key element of digital transformation as they can cause a disruption but also can be a response (Vial, 2019) by implementing them in customer experience, operations, and business model (Sebastian et al., 2017). Some of the key technologies that are used in digital transformation are social, mobile, analytics, cloud, and Internet of things [IoT] (SMACIT) (Sebastian et al., 2017) but also organizations adopt other technologies like Artificial Intelligence, Blockchain, Robotics, and Virtual Reality; which create opportunities and threats for the companies. Nevertheless, we choose to focus on three digital technologies (Artificial Intelligence, Blockchain, and Internet of Things) which cause radical changes in organizations existing customer experience and operations.

Since the beginning of digital transformation, the retail industry is considered among the pioneers that implement digital technologies in every business aspect. Westerman, Tannou, Bonnet, Ferraris, & McAfee, (2012) characterize the retail industry as “Digirati”, organizations that consider leaders in sector's digital transformation efforts by investing in digital technologies to foster customer experience and internal operations and in the same time they develop advanced leadership capabilities to foster and spur digital transformation inside the organization. Part of the retail industry is the

fashion industry in which digital technologies have caused a variety of disruptions not only in customer experience and operations but also in business models.

Burberry was among the first fashion brands that integrate digital technologies in customer experience and operations as a response to low growth rates and innovation. The early digital transformation efforts were focused on front-end and back-end operations. The improvements in customer experience include a new marketing team, new customer services like live streaming of runway shows, partnerships with social media players, and relaunch of the site. On the other hand, the back-end operations include the adoption of a new platform and support store employees with iPads to advance its everyday task and to offer new services to customers (Bonnet, 2012).

The digital transformation process of Burberry begun in 2006 (Bonnet, 2012), but since then customers and organizations have adopted a variety of digital technologies to support their organization, and in many cases, digital technologies dictate organization's digital strategy. In this paper, as mentioned above, we focus on three main digital technologies which cause changes in customer experience and operations; presenting digital technologies that have been widely adopted like Artificial Intelligence (AI) which include recommendation systems and chatbot, and technologies that are going to play a key role in industry's future such as Blockchain, and Internet of Things. By shedding light on these key digital technologies and point out their main applications and impact we will guide organizations to select more suitable technologies according to their digital strategy and prevent misplaced investments.

The paper follows the above structure: first we present Artificial Intelligence technology and its uses in fashion industry and then we focus on state-of-art technologies like blockchain and IoT. Finally, we provide conclusions, future research guides, and the limitations of this research.

DIGITAL TECHNOLOGIES IN FASHION RETAIL INDUSTRY

In previous years, digital transformation in fashion retail industry was focused mainly on creating an online store; however, in recent years digital transformation in fashion industry tries to incorporate digital elements in physical store experience and offer a variety of services in both channels. In many cases, organizations complement physical experience with digital services or integrating digital devices through the purchase journey like real-time information about the product (Hagberg, Sundström, & Nicklas, 2016). As mobile devices and digital technologies, in general, are part of customer journey and cause changes in consumer behavior (Hagberg et al., 2016) organizations are obligated to adapt to new consumption models that are influenced by technological progress (Grewal, Motyka, & Levy, 2018).

Artificial Intelligence in Fashion Industry

Artificial Intelligence (AI) in general refers to a set of technologies that focus on the ability of computers to mimic human intelligence and make the right decisions when needed. Furthermore, AI can process and retrieve data either by responding to users' requests or by taking decisions based on previous data and knowledge (Tredinnick, 2017). These aspects are valuable for fashion industry organizations, as they help organizations not only to offer additional value to its customers but also to advance their operations by advancing the physical experience and offering new styling services to customers (Kashyap, 2018).

As the majority of the fashion brands maintain an online store, they adopt recommendation systems; a software application that proposes products that match users' preference and taste (Ricci, Shapira, & Rokach, 2015) or offer personalized tips according to customer's style, body shape (Guan, C., Qin, S., Ling, W., & Ding, 2016), purchase history, search history, and gathered data from other users with similar preferences, demographics, etc. (Guan, C., Qin, S., Ling, W., & Ding, 2016). These predictions not only help fashion brands to offer additional services but also help them make the right decisions during the design phase, and create products that meet customer preferences, needs, and style (Wang, Zeng, Koehl, & Chen, 2015).

Another use of AI is chatbots; a computer program designed to represent a clear and comprehensive short- or long-term discussions with customers and to gather information through a series of questions. Chatbots can be a useful solution when customers are incapable to make decisions due to an extended variety of products and poor navigation structure. Chatbots through discussion and questioning process, navigate customer, help them choose the appropriate product (Gupta, Borkar, De Mello, & Patil, 2015), inform them about current trends and adaptability, solve their problems and save time (Chung, Ko, Joung, & Kim, 2018). For example, Levi's has a wide variety of jeans which can be overwhelming for customers. Thus, they partner with a startup named Mode.ai to create a virtual stylist which helps customers find products based on preferences like comfort, length, and size information (not only in Levi's products) to recommend appropriate products and product size (Mau, 2017). Functions like this help organizations improve important KPIs as product return rates, customer satisfaction, brand loyalty, and increase customers' positive reviews which boosts the company's profits (Chung et al., 2018).

Blockchain

Blockchain technology allows the collection, storage, and distribution of digital transactions by relying on cryptographic algorithms to ensure data security, secure communication, and system transparency. This is achieved with the help of the peer-to-peer distributed network which allows users to transact without interventions as each transaction is permanently recorded in the public ledger book (Mo, Su, Wei, Liu, & Guo, 2018), where all the approved transactions, are verified, stored in the block, and are connected to previous ones to create the blockchain chain (Tapscott & Tapscott, 2017).

Before a product reaches the stores and is available for sale, it goes through various stages until it completes its journey. As consumers become more responsible and interesting about production process; fashion brands can exploit blockchain capabilities to inform customers about the production process including working conditions, raw materials, and verify product authenticity (Abeyratne, S. A., & Monfared, 2016). Blockchain technology as a distributed and decentralized alternative enables information transparency, reliability, and guarantees data security (Sidorov et al., 2019). In order to record and verify each production stage and offer this information to customers (with the use of QR code); designer Martine Jarlgaard partner with a blockchain technology company Provenance, a consultancy A Transparent Company and the London College of Fashion's Innovation Agency to implement blockchain in production line (Arthur, 2017). Combining blockchain with other technologies, such as RFID technology can be very useful and reduce product counterfeiting because it gives organizations the ability to monitor all products in the supply chain due to the unique electronic code in the RFID tags. As the product goes through various stages, new information is added, which proves whether the products have passed through a legitimate supply chain (Toyoda, Mathiopoulous, Sasase, & Ohtsuki, 2017).

Internet of Things

The main idea of Internet of Things technology (IoT) is to connect multiple objects, thus it attracts both academic and industrial community attention (Nukala et al., 2016). Part of IoT could be smart devices and physical objects, only when they are combined with other types of technology like RDIF tags (Aazam, Khan, Alsaffar, & Huh, 2014). As the literature indicates, Blockchain technology and IoT technology can be combined with other technology application, like RFID, wireless sensor networks for data analysis, cloud computing, and Internet protocols, and create an IoT system (Arseni, Halunga, Fratu, Vulpe, & Suciu, (2015); Nukala et al., (2016)).

In the fashion industry, RFID technology is increasingly being used because it is a method to identify and automatically store information. Combining an RFID tag with a reading device and a data management system organization can create an IoT system. Thus, the tag becomes an identification system, which records product history from the processing stage, throughout the supply chain and to retail distribution (Meraviglia, 2018). In physical stores, this technology not only can be used to enhance the consumers' shopping experience by providing real-time personalized information (Perry, P., Kent, A., & Bonetti, 2019); but also can be used by organization for greater product placement. This level of services can be achieved by integrating a label into various locations, such as mirrors, self-service systems, and products (Perry, P., Kent, A., & Bonetti, 2019) or by using store sensors. For example, Hugo Boss uses in stores heat sensors to monitor customers' movements and place high-quality products in high traffic locations (Gregory, 2015). In fashion industry organizations that adopt IoT systems have a significant impact on organizations' financial and non-financial results regardless of the industry. More specifically, IoT systems can improve the in-store consumer experience, and general consumer behavior by offering better service quality and personalized offerings and improve return on investment (ROI) KPI (Papahristou, Kyratsis, Priniotakis, & Bilalis, 2017).

CONCLUSIONS

Digital technologies have caused changes both in customer's behavior and in operations. As customers becoming more demanding and are interesting in the production process and manufacturing details organizations have to digitally transform the supply chain and customer experience to fulfill this need. Besides, as financial aspect is an extremely important parameter for digital transformation (Matt et al., 2015) organizations have to invest in digital technologies that will fit their digital strategy and increase their value proposition. AI, Blockchain, and IoT can be part of the supply chain to fulfill customer needs and expectations and to improve operations. However, as it is clear, adopting one particular technology in many cases is not enough as organizations have to create a system to increase the added value and competitive advantage. For example, Blockchain technology can be combined with RFID or QR codes to be more manageable and ease of use as showed in the case of designer Martine Jarlgaard.

Despite the chosen digital technology, organizations have profound benefits from implementing digital technologies in customer experience and operations (Table 1). Analyzing the collected data can improve organizations knowledge about customer needs or preferences, customer movement inside the store, and be input for future strategic or production decisions. On the other hand, these digital technologies help organizations monitor and improve supply chain operations as they are transparent for both entities. In general, these improvements can add value to the organization by increasing brand loyalty, sales rate, and customer satisfaction.

Table 1. Benefits from implementing AI, Blockchain, and IoT in customer experience and operations.

Digital Technology	Type of Use	Benefits
Artificial Intelligence	Recommendation System	Improve customer experience Create an input during design phase
	Chatbot	Decrease product return rate Increase customer satisfaction- Brand loyalty- Positive reviews
	Supply Chain Implementation	Transparent supply chain -Elimination of counterfeit products Information available to customers
Internet of Things	Supply Chain Implementation	Improvements in customer experience- consumer behavior Valuable information/knowledge for organization Improved KPIs (sales rate, Return of Investment (ROI))

The above analysis presents some of the key benefits of adopting state-of-art digital technology and could be a guide for managers when they develop organization digital strategy. These digital technologies can be a valuable source of information that will improve organizations future digital technology investments and production decisions. However, there are some limitations. First, our conclusions regarding the benefits of these digital technologies are based on a limited number of sources as it is an introductory theoretical approach. Thus, future research can shed more light on related literature and expand the benefits list. Second, the benefits of each technology are based only on literature review. This creates an opportunity for future research to expand this research by conducting a survey or analyze different organizations case studies to verify the above-mentioned outcomes.

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Social networking services and travel information: Evaluating users' perceived value and trust

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Abstract

Social media platforms are used by consumers in order to share information, pictures, and videos. Social networking is a new way for customers to interact, communicate and build relationships among them. Especially in the tourism industry, social media have changed the way tourists search, read, handle and trust information and help them to collaborate in order to produce information for destinations. Tourists create the content of social media by reading, using and sharing information before, during and after their travel. User Generated Content (UGC) is a significant tool for tourists in order to share information and make travel decisions. By sharing travel encounters through content, pictures, and videos, clients improve the free data accommodated potential travelers with respect to new markets, new subjects and sensitive issues. Feedback giving by customers through UGC is fast, up-to-date, and available everywhere and it is a way of word-of-mouth in the digital age. Potential customers spend time reading online reviews and communicate with other travelers because they attempt to be satisfied by their travel planning decision. Thus, it is important to secure privacy and trust for users when they share travel information. However, more research concentrating on consumer behaviour specifically in respect of trust-based aspects, privacy concerns, and other associated prevalent issues. Therefore, the purpose of this paper is to examine the factors influence users' perceived value and trust in acquiring travel-related information from social networking services. Data were collected from Facebook users that have shared travel information and analyzed using Regression Analysis. This paper contributes to social networking services users' behaviour and provides managerial implications to boost more acquisition of travel information from social networking services.

KEYWORDS

Social networking; Travel planning; User generated content; Perceived value; Trust.

INTRODUCTION

Social media platforms are used by consumers in order to share information, pictures, and videos. Social networking is a new way for customers to interact, communicate and build relationships among them (Alalwan et al., 2017; Leung et al., 2017; Zeng and Gerritsen, 2014). Especially in the tourism industry, many technological changes and innovations have been made in order to increase customers' satisfaction (Kitsios, 2000; Kitsios and Kamariotou, 2019; 2016; Kitsios and Zopounidis, 2007). Social media have changed the way tourists search, read, handle and trust information and help them to collaborate in order to produce information for destinations. Tourists create the content of social media by reading, using and sharing information before, during and after their travel. User Generated Content (UGC) is a significant tool for tourists in order to share information and make travel decisions. By sharing travel encounters through content, pictures, and videos, clients improve the free data accommodated potential travelers with respect to new markets, new subjects and sensitive issues. Feedback giving by customers through UGC is fast, up-to-date, and available everywhere and it is a way of word-of-mouth in the digital age (Blazevic et al., 2013; Leung et al., 2017; Merchant et al., 2010; Schuckert et al., 2015; Ukpabi and Karjaluo, 2018).

The significance of UGC in the travel industry can be justified by the following reasons. First, a travel is a unique experience for each traveler. Thus, buyers need to settle on the best travel choices so as to benefit as much as possible from the experience, and they try to do as such by understanding surveys and remarks from individual consumers. Potential customers spend time reading online reviews and communicate with other travelers because they attempt to be satisfied by their travel planning decision. Second, the travel industry can't be experienced before utilization. Tourists consider by sharing information that they can help other tourists select the correct travel service and make informed

purchasing decisions that will satisfy them and achieve pre-purchase expectations. Therefore, buyers depend on the information provided by other travelers. Finally, reviews from individual customers are regarded legit and dependable, so travelers depend on them as a trustworthy wellspring of data for their travel decisions (Lu et al., 2018; Schuckert et al., 2015; Sotiriadis, 2017; Ukpabi and Karjaluoto, 2018).

Previous researchers have indicated that consumers using social networking sites are concern about their privacy. They have tried to speculate the factors that affect social networking sites end-users' supposed value and trust when obtaining information that is linked to travel from social networking platforms (Author, 2016; Sussman and Siega, 2003). However, several studies focus on customer behavior especially in areas concerned with trust-based, privacy fears, and other related prevalent concerns. Therefore, the purpose of this paper is to examine the factors affect the end user's supposed value and trust in obtaining information related to travel from social networking platforms. Data collected from Facebook users that have shared travel information was analyzed using Regression Analysis.

The paper is structured as follows: Section 1; a brief introduction of the subject, section 2 is the theoretical background on the factors that influence users' perceived value and trust in obtaining information that is travel-related from social networking sites, Section 3 explains the methodology, Section 4 shows the results while Section 5 is the discussion and conclusion.

THEORETICAL BACKGROUND

In electronic commerce, trust has been identified as an important precursor in the customer decision-making process. Customer trust is reduced when there is an existing fear on the security, credibility, and competence issues surrounding any system that customers might want to make use of. Once any fear of distrust is established, customers develop a strong perception of uncertainty for that system, as a result, they are not willing to make use of it but ready to make use of other services or option elsewhere and consequently disposed to spread undesirable word-of-mouth potential users of the system (Kyriakopoulou et al., 2019; McKnight et al., 2002). Social networking sites end-users acquire information value by obtaining valuable information that is travel-related from acquaintances or expert information providers on Social networking sites (Kim and Jang, 2018). Social networking sites users display a higher level of concern for their privacy as they worry that their personal particulars may be disseminated online by Social networking sites developers or online firms without their consent, thereby rendering them powerless to protect themselves (Chang et al., 2017; Wang and Herrando, 2019). When Social networking sites end users sense high dangers linked with their possible e-commerce and m-commerce activities, and encountered any challenge in recovering information connected to travel and tourism issues via social networking sites, their supposed value and trust level reduce (Chang et al., 2017; Wang and Herrando, 2019). Supposed enjoyment to be a vital precursor of user supposed value and trust in regards to electronic systems. This class of end-users are overcome by the level of satisfaction they get and are likely to look away from the weaknesses in the electronic system – that is, the satisfaction is of more importance to them than the possibility of their security been broken (Rouibah et al., 2016).

Based on the analysis of the existing literature, the following hypotheses are defined:

Table 1.Hypotheses

Hypotheses	References
H1: Perceived value has an important positive effect on SNS users' trust in obtaining information that are travel-related from SNS.	Huang et al., 2017; Lee et al., 2014; Mohd Suki and Mohd Suki, 2019
H2: Privacy has an important negative influence on SNS users' perceived value of the travel-related information obtained from SNS.	
H3: Privacy concerns have a significant negative impact on SNS users' trust in obtaining information that are travel-related from SNS.	
H4: Perceived risk has a substantial negative effect on SNS users' perceived value of the travel-related information obtained from SNS.	
H5: Perceived risk has a significant negative impact on SNS users' trust in obtaining information travel-related from SNS.	
H6: Perceived enjoyment has an important positive effect on users' perceived value of the travel-related information obtained from SNS.	

H7: Perceived enjoyment has a significant positive influence on SNS users' trust in obtaining travel-related information from SNS.

METHODOLOGY

To measure the factors that affect users' perceived value and trust in obtaining information that are travel-related from social networking providers, a questionnaire was designed and distributed among 300 Facebook users with 266 completing the survey. Variables were related to privacy concerns, perceived danger, perceived satisfaction, perceived value and trust in travel-related information. System quality determines the fulfillment an end-user obtains when the e-justice system is used. The items were adapted from previous researchers (Huang et al., 2017; Lee et al., 2014; Mohd Suki and Mohd Suki, 2019). To operationalize the above-mentioned constructs, a Five-point Likert scale was used. Data were analyzed using Regression Analysis.

RESULTS

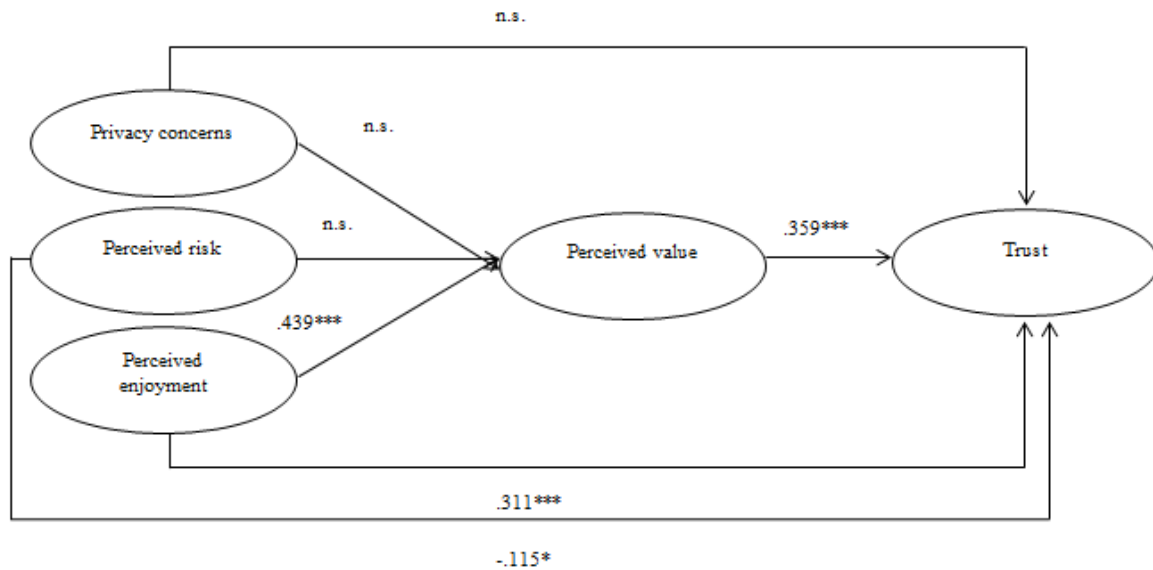
Table 2 presents the results of Regression analysis for the two models. In the first model, the dependent variable was Perceived value and independent variables were Privacy concerns, Perceived risk and Perceived enjoyment. In the second model, the dependent variable was Trust and independent variables were Privacy concerns, Perceived risk, Perceived value and Perceived enjoyment. The path coefficient between Perceived value and Trust was positive and statistically significant ($\beta = 0.359$, $p < 0.001$). Thus, H1 was supported. Furthermore, there was a positive but not statistically significant relationship between Privacy concerns and Perceived value ($\beta = 0.064$, $p < 0.05$) and Privacy concerns and Trust ($\beta = -0.063$, $p > 0.05$). Thus, H2 and H3 were not supported. The path coefficient between Perceived risk and Perceived value was positive but not statistically significant ($\beta = 0.099$, $p > 0.05$). Thus, H4 was not supported. There was a negative and statistically significant relationship between Perceived risk and Trust ($\beta = -0.115$, $p < 0.05$); thus, H5 was supported. Figure 1 presents the results of Regression analysis. There was a positive and statistically significant relationship between Perceived enjoyment and Perceived value ($\beta = 0.439$, $p < 0.001$) and Perceived enjoyment and Trust ($\beta = 0.311$, $p < 0.001$). Thus, H6 and H7 were supported.

Table 2 Regression Results

Independent variables	β	t	R ² (Adj.)	F
Model 1			.234	27.923
Privacy concerns	,064	1.089		
Perceived risk	,099	1.650		
Perceived enjoyment	,439	7.883		
Model 2			.293	28.396
Privacy concerns	-.063	-1.103		
Perceived risk	-.115	-1.986		
Perceived enjoyment	.311	5.227		
Perceived value	.359	6.046		

*Significance at <0.05, **Significance at <0.01, ***Significance at <0.001

Figure 1 Conceptual model



CONCLUSIONS

This paper examined the factors that affect users' perceived value and trust in obtaining information that are travel-related from social networking sites. The results show that the more the perceived value of the travel-related information obtained from social networking sites, the higher the chances of social networking sites end-users to build robust trust in that information. They appear to gather large amounts of knowledge from other online users and distribute diverse forms of travel-related information via social networking sites. This process enables them to obtain much important travel-related information and at the same time expand their social interactions. The higher the privacy fears social networking sites end-users have, the lesser the perceived value of the travel-related information they obtained from social networking sites. They are greatly worried about the likelihood of unidentified capture of their private information on the web by social networking sites provider or online companies without their permission. Results have shown that the higher the privacy worries users of social networking sites have, the lesser the confidence in the travel-related information obtained from social networking sites. They are against the view that social networking sites are secured and reliable channels for such business. They are also of the view that their personal information would be poorly handled and protected by social networking sites providers. The important linkages state that as social networking sites users have low perceived risks, they tend to develop robust trust in the travel-related information obtained via social networking sites. The enjoyable experience encourages the feel-good experience among social networking sites users, and in turn, these feelings produce greater confidence in the travel-related information obtained from social networking sites.

The findings of this study have applied implications. Managers in the tourism sector should improve the pleasurable and satisfying areas of their websites to enable increased sourcing of travel-related information from social networking sites. To achieve this, the websites' functionality should be upgraded by incorporating video and audio, thereby increasing high levels of interaction and increasing commercial opportunities. Furthermore, managers in the tourism sector should constantly upload real-time and reliable information about travel-related products and services, destination information, and tourism promotional messages. Additionally, efforts should be made to increase the level of confidence in their social networking sites.

The limitations of this study which serve as a guide for future study are; the size of the sample, which could be increased to expand the potential for generalization. Samples can also be collected from different geographical areas which will help to increase the generalization potential even more. Additionally, loyalty, habit, and social self-efficacy may be considered as mediating variables.

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UNESCO Chair Con-E-Ect: Promoting Riparian Areas and Deltas Sustainability.

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Abstract

Riparian areas and deltas are unique ecosystems and ecotones (transition zones) between the aquatic and terrestrial ecosystems. Their uniqueness leads to the many unique ecosystem services they offer and is the reason why they have been utilized for thousands of years. This has led to their degradation and their conservation and preservation has become a main priority worldwide. Finally, climate change is expected to severely impact these two ecosystems. These are the main reasons why the UNESCO Chair on the Conservation and Ecotourism of Riparian and Deltaic Ecosystems (Con-E-Ect) was established at the International Hellenic University in May 2016. The objective of Con-E-Ect is to collaborate with national, regional and international organizations and stakeholders, in order to develop an International Common Strategy Framework for the Conservation and Ecotourism of Riparian and Deltaic Ecosystems. Con-E-Ect is accomplishing its objective through innovative international and national research projects. Through these activities, Con-E-Ect promotes integrated water resources management principles, ecosystem-based approaches, and nature-based solutions to be adopted by policy makers, water managers and stakeholders for the sustainable management of these ecosystems. In addition, it is building partnerships with government agencies, organizations and municipalities of the region while also participating in EU and nationally funded projects. Con-E-Ect based on its research project is addressing the following Sustainable Development Goals (SDGs): Clean Water and Sanitation, Life on Land, Life Below Water, Climate Action, Quality Education, Sustainable Cities and Communities and Partnership for the Goals. The awareness on the importance and best practices to conserve and maintain riparian areas and deltas in Greece and in the region has been steadily increasing.

KEYWORDS

Sustainable Development Goals, Ecosystem Services, Integrated Water Resources Management, Ecosystem-based Approaches, Nature-based Solutions.

INTRODUCTION

Riparian and deltaic areas offer many and unique ecosystem services to humans (Naiman et al. 2005). This is the reason why they have been utilized for thousands of years and many human settlements had been and continued to be established in or around them (Syvitski et al. 2005). These ecosystems are ecotones, transition zones between terrestrial and aquatic ecosystems that leads to their unique environmental conditions that differentiate them from their surrounding ecosystems (National Research Council 2002). The higher soil moisture due to the proximity to the aquatic water bodies along with frequent flood disturbances lead to unique soils (typically hydric) and fluviogeomorphic formations. The above lead to the establishment unique vegetative assemblages that are hydrophilic and highly biodiverse (Zaimis et al. 2010). The different (hydrophilic), denser and taller vegetation distinguishes them from the surrounding landscape, especially in semi-arid and arid environments such as the Mediterranean basin (Zaimis et al. 2011).

Riparian areas are typically adjacent to streams, rivers and lakes with linear boundaries that are not always clearly defined, as they may change from year to year depending on the hydrologic conditions of the adjacent water body (Zaimis et al. 2010). Deltas are sedimentary deposits as the river waters enter standing or slow-moving water bodies (e.g. lakes, seas, oceans) (Nicholls et al. 2007). From a landscape perspective they appear as protuberances with a shape similar to the Greek letter Δ along the shoreline (Bhattacharya 2011). The health and process of these ecosystems are interconnected with each other and when managing at the watershed scale special attention should be given to both riparian areas and deltas (Zaimis and Emmanouloudis 2012).

The intensive utilization of the riparian areas and deltas for thousands of years, especially in the Mediterranean, is the main reason why many scientists considered them as the most degraded ecosystems (Naiman et al. 2005). The main

culprits that have degraded these ecosystems are agriculture, urbanization, roads, mining, industrial uses, and surface and ground water withdrawal (Iakovoglou et al. 2013; Zaimis et al. 2019a). Finally, climate change is expected to further exacerbate these pressures by altering the hydrologic regimes causing higher surface runoff and stream flows, higher sediment transport capacity and increased soil erosion (Giupponi and Shechter 2003). Along the coastal areas (e.g. deltas) erosion and sea-level rise are expected to degraded them (Nicholls et al. 2007).

The many and different pressures riparian areas and deltas have experienced that and led to the significant degradation of their ecosystem services have promoted their protection by international treaties, such as the Ramsar Convention, and the European Commission with the Natura Network. The continued population growth along with the climate change impacts require future management plans to utilize innovative methods and approaches for their sustainability. Specifically, these plans need to be based on integrated water resources principles, ecosystem-based approaches and nature-based solutions.

The goal of the UNESCO Chair “Con-E-Ect, Conservation and Ecotourism of Riparian and Deltaic Ecosystems” that was established in May of 2016 at the Department of Forestry and Natural Environment Sciences of the International Hellenic University (IHU) of Greece is to enhance the sustainability of the two ecosystems. This paper describes the main activities, approaches and projects of the Chair has implemented to meet the UNESCO Sustainable Development Goals (SDGs) that pertain to these two ecosystems.

UNESCO CHAIR CON-E-ECT

The objective of Con-E-Ect is to elaborate an International Common Strategy Framework for the Conservation and Ecotourism of Riparian and Deltaic Ecosystems (Emmanouloudis et al. 2017). This will be accomplished by joining forces with national, regional and international stakeholders and organizations. The goal of the Framework is to govern sustainably the protection, study, development and ecotourism of deltaic and riparian environments. The focus will initially be in the Balkans and the Mediterranean regions with the long-term goal the Framework to be applicable worldwide. The Framework’s goals will be accomplished through the promotion of research by collecting and assessing data, dissemination of research findings, training and awareness actions addressed to various target groups, so that all stakeholders will harmonize their activities towards the sustainable management of riparian and deltaic ecosystems.

Con-E-Ect is located in Central and Eastern Macedonia and Thrace of Greece. In this region a unique ecosystem, which stretches over a length of 300 km and consists of multiple major riparian and deltaic ecosystems is present. The specific ecosystems that Con-E-Ect will initially focus its efforts on include the: a) Nestos River Delta, b) Evros River Delta, c) Axios, Loudias, Aliakmon delta, d) Lakes Vistonida and Ismarida, e) Lake Kerkini, f) Lakes Volvi and Koronia, g) Frakto Virgin Forest, h) Mount Olympus, i) Dadia Forest and j) Nestos Corridor. By establishing Con-E-Ect in this region it enables UNESCO to capitalize this natural “laboratory.” By utilizing this natural laboratory, Con-E-Ect will develop this International Common Strategy Framework for the Conservation and Ecotourism of Riparian and Deltaic Ecosystems (Emmanouloudis et al. 2017).

INNOVATIVE MANAGEMENT APPROACHES

Climate change, urbanization, population growth and the increased water footprint will exacerbate the pressure on semi-aquatic ecosystems such as riparian areas and deltas. The current management plans in most countries will not be able to meet future needs. This is especially true around the Mediterranean Sea that is water scarce. New innovative management approaches need to be adopted and implemented that are more environmentally friendly and based on natural environmental processes. Such approaches that the UNESCO Chair Con-E-Ect promotes are: a) Integrated Water Resources Management (IWRM), b) Ecosystem-Based Approaches (EBA) and c) Nature-Based Solutions (NBS) These are described in more detailed in the following sub-sections. Some of the main reasons why these approaches are being more accepted worldwide are because they promote: a) Climate change adaptation and mitigation, b) Disaster risk mitigation, c) Food production security, d) Biodiversity and ecosystems, e) natural resources, and especially water, sustainable management, f) transboundary collaboration, g) health risk reduction, h) Sustainable urban development, i) Collaboration in the management of fresh water and coastal water and of land and water and j) management of the water-energy relationship.

Integrated Water Resources Management (IWRM)

Integrated Water Resources Management (IWRM) is a bottom up approach that was developed by practitioners. Its key principles are (Hassing et al., 2009): 1) Freshwater is a finite and vulnerable resource, essential to sustain life, development and the environment, 2) Water development and management should be based on a participatory approach involving users, planners and policy makers at all levels, 3) Women play a central part in the provision, management and safeguarding of water, 4) Water has an economic value in all its competing uses and should be recognized as an economic good. Another key element is that planning should be based on a watershed or basin, the natural unit for water resources management (Zaimes and Emmanouloudis 2012). IWRM with management instruments, legislations, policies and institutional frameworks tries to achieve balance for “water as a livelihood” and “water as a resource.”

Ecosystem-Based Approaches (EBA)

Ecosystem-based approaches (EBA) are adaptation strategies that use biodiversity and ecosystem services (CBD 2009). Overall, it is a relatively new concept that has not been used extensively, especially in the Mediterranean. To overarching objective is to benefit communities or buffer them against adverse effect (e.g. climate change, disaster) through the conservation, sustainable management, and restoration of ecosystems (Munang et al. 2013). These approaches focus on the benefits humans can derive from biodiversity and ecosystem services. In many cases these benefits can help mitigate climate change. The above mean that EBA area people-centric concept since it acknowledges that human resilience depends on the maintenance and conservation of ecosystems. Finally, another major benefit from such approaches are that they are cost-effective and be accessible to the rural and poor communities in developing countries.

Nature-Based Solutions (NBS)

More and more scientists and researchers but also the general public are recognizing that in order to find sustainable and viable solutions we need to look into and utilize nature (Cohen-Shacham et al. 2016). Through the many years of civilization, it is clear that we need to working with nature, and not against it because these resources can be used more efficiently while building a more competitive and greener economy. Specifically, these new management plans need to use and implement natural ecosystems properties and services. These solutions need to be implemented in an 'engineered' way, especially in heavily human modified environments (e.g. urban areas). Overall, these nature-based solutions (NBS) provide sustainable, cost-effective, multi-purpose and flexible alternatives for various goals set by the stakeholders (Zaimes et al., 2019b). In regard to the societal needs, NBS are inspired by nature that provide environmental, social and economic benefits to communities while also enhancing their resilience cost-effectively. Through these interventions, landscapes, sea scapes and even cities incorporate diverse natural features and processes. These solutions are typically locally adapted and highly resource-efficient. Finally, these new solutions can help create new jobs and economic growth, through the manufacture and delivery of new products and services, while at same time benefiting biodiversity and supporting numerous ecosystems services.

CON-E-ECT PROJECTS

To meet its main objectives, the Chair Con-E-Ect is involved in many international and national projects. All projects are incorporating integrated water resources management, ecosystem-based approaches and nature-based solutions. For each project the Sustainable Development Goals (SDGs) they apply to are stated.

International Projects

1) “Innovations in Water Education Programs: Enhancing Water Security and Socio-economic Development in the Eastern Mediterranean under Climate Change” with the acronym “WaSec” goal, is to bring together and strengthen the cooperation between companies and universities through the development of new courses in Water Resources Management, while taking into consideration potential climate change impacts. These new courses will incorporate innovative and adaptive learning and teaching methods and will focus on the Eastern Mediterranean region. It should lead to a new culture of working relationships among universities and enterprises that will allow universities their better integration within the larger society. This project is co-funded by the ERASMUS + Program of the European Union and for more information check <http://wasec.just.edu.jo/Pages/default.aspx>. WaSec pertain to the SDGs: a) Quality

Education (SDG 4), b) Clean Water (SDG 6), c) Climate Action (SDG 13), d) Life Underwater (SDG 14), e) Life on Land (SDG 15) and f) Partnership for the Goals (SDG 17).

2) Another project is the “Cooperation for fusing skills on Cloud-based Open GeoInformatics: Innovative Environmental Management’ with the acronym “FuseGI.” This project is funded by Erasmus+ KA2 – Cooperation for innovation and the exchange of good practices – KA203 – Strategic Partnerships for higher education. FUSEGI aims to deliver practical problem-solving GeoInformatics (GI) Skills and develop professional GI capabilities to postgraduate students, through the development of an active GI network and provision of up-to-date curricula and modern teaching systems based on cutting – edge ICT tools in order to address training needs in environment and health risk management. Fuse GI covers the SDGs: a) Good Health (SDG 3), b) Quality Education (SDG 4), c) Climate action (SDG 13), and d) Partnership for the Goals (SDG 17).

3) The “MONITOX” project is funded from the Joint Operational Program BLACK SEA BASIN 2014-2020. The full title is “Black Sea Basin interdisciplinary cooperation network for sustainable joint monitoring of environmental toxicants migration, improved evaluation of ecological state and human health impact of harmful substances, and public exposure prevention.” The project aims to enhance regional cross-border cooperation to improve joint monitoring of environmental toxic pollution and better sharing and exchanging of new analysis methodology, data and information on the ecological state and human health impact of harmful substances. For more information please visit <https://www.monitox.ugal.ro/>. MONITOX covers the SDGs: a) Good Health (SDG 3), b) Clean Water (SDG 6), c) Climate action (SDG 13), d) Life underwater (SDG 14), and e) Partnership for the Goals (SDG 17).

National Projects

1) The “Avdera Research Project” is a collaborated effort with the Municipality of Avdera in Greece. The purpose of the program agreement was the promotion of ecotourism for the municipality by mainstreaming ecotourism policies. The SDGs it meets are: a) Economic Growth (SDG 8), b) Sustainable Cities and Communities (SDG 11), and c) Partnership for the Goals (SDG 17).

2) “Monitoring and Utilization of Riparian Areas of Drama Municipality” is being implemented in collaboration with the Municipality of Drama, Greece. In this project firstly the current condition of the riparian areas and streams that run through the city of Drama are being assessed. In addition, stream water quality and quantity measurements are taken. This data will be the basis to develop a management plan to enhance the functionality and ecosystem services of the urban riparian areas in a sustainable way, while at the same time mitigating the impacts of climate change and improving the quality of life for the city dwellers and attracting new tourists to the city. The SDGs it pertains to are: a) Clean Water (SDG 6), b) Sustainable Cities and Communities (SDG 11), c) Climate action (SDG 13), d) Life on Land (SDG 15) and e) Partnership for the Goals (SDG 17).

3) The “Eski-Kapou Research Project” was funded by Kavala Municipal Enterprise “Dimofelia.” Through this project the current conditions in regard to the flora and fauna and other environmental factors (e.g. erosion) of the Eski-Kapou area (near Kavala, Greece) are being recorded. Based on this information a manual guide and behavioral code will be developed for the potential visitors. The overall goal is to enhance ecotouristic and aesthetic values of the Eski-Kapou hill, particularly for the residents of Kavala but also other tourists. The SDGs it addresses are: a) Economic Growth (SDG 8), b) Sustainable Cities and Communities (SDG 11), c) Life on Land (SDG 15) and d) Partnership for the Goals (SDG 17).

CONCLUSIONS

Con-E-Ect, despite being a relatively young UNESCO Chair, has been very active by establishing many partnerships and being involved in many international and national research projects. Through these partnership and projects, Con-E-Ect is promoting integrated water resources management, ecosystem-based approaches and nature-based solutions while also addressing many of the SDGs (e.g. 3, 4, 6, 8, 11, 13, 14, 15 and 17). Through these partnerships and projects new best management practices are being developed for riparian areas and deltas while their importance to numerous groups is being increased and enhanced through dissemination and awareness actions that increase their conservation and protection in Greece, the Balkan and the Mediterranean.

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Quantifying Enterprise Coherence – A Design Based Comparison Of Calculation Methods

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Abstract

Coherence between various enterprise facets is essential for optimal performance. A quantitative expression for enterprise coherence has therefore the opportunity to function as a leading indicator for enterprise performance, but is currently lacking. This research focuses on the quantification of 'enterprise coherence', in order to aid enterprise architecture governance and realize more sustainable enterprises. The Enterprise Coherence Index (the EC-index) to measure enterprise coherence is proposed. Design development of the EC-index is guided by a well-established design science methodology. One of the identified components of the EC-index is an enterprise coherence calculation engine. The enterprise coherence calculation engine requires a quantification method in order to calculate coherence. Quantification models from different domains exist. Four different candidate quantification models are selected, and the selection is made plausible through a literature overview based on key search terms. All approaches are based on a graph model. For the domain of the enterprise a bipartite network of 'direction statements' versus enterprise decisions is chosen. To aid in developing the EC-index, quantification methods are compared with data from two historical cases. It is shown that some models can already be eliminated based on these cases, and that other methods can be unified. It will be shown that coherence contribution of individual decisions can be expressed as a number, based on their supportiveness of the enterprise's purpose. This paper aims to contribute to the domain of governance and policy modeling as well as to organizational decision making.

KEYWORDS

Architecture Governance, Enterprise Architecture, Enterprise Coherence, Enterprise Coherence Index, General Enterprise Architecting, Quantification of Coherence.

INTRODUCTION

Within General Enterprise Architecting (GEA) (Wagter, 2013), enterprise coherence is defined as 'the extent to which all relevant aspects of an enterprise are connected, in such a way that these connections facilitate an enterprise obtaining/meeting its desired results' (Wagter, 2013). Application of the GEA method within an enterprise increases its governance capacity, and its coherence permanently (Wagter, 2013). Quantitative expression of enterprise coherence would enhance understanding enterprise coherence. While multiple quantifications exist in modern EA (see e.g. (Monahov, 2014)), a generic metric for enterprise coherence is lacking. This while with growing maturity and growing financial pressure on EA initiatives, enterprise architects need quantitative models and metrics (Monahov, 2014). As solution we will create an instrument that we call the Enterprise Coherence Index (the EC-index). The EC-index measures enterprise coherence. The heart of the EC-index will be formed by an engine that calculates enterprise coherence. For the calculation of enterprise coherence there are a number of possible candidate calculation models. This paper gives an overview of the EC-index in section 2, presents a comparison of candidate models in section 3, and describes the research approach in section 4. Two historical cases will be elaborated in section 5, and conclusions are discussed in section 6. Finally, section 7 states subjects for further study. This paper is part of a larger study to describe the design of the EC-index.

BACKGROUND

A first high level literature study has been carried out to achieve an overview of available models, and identify suitable ones. A systematic literature review is left for a next iteration, when there is more direction for the model, e.g. based on outcomes of experiments. This first study of literature led to the identification of four candidate methods (labeling is solely for use in this paper):

1. TEC: Theory of Explanatory Coherence (TEC) (Thagard and Iasmith, 2002 ; Thagard, 2000; Thagard and Verbeurgt, 1998).
2. S_TEC: TEC application based on notion of Similarity (Confanoli et al., 2017)

3. LC: Local Coherence within machine learning context (Guidaudeau and Strube, 2013; Parveen and Strube, 2015)

4. QM: Based on coherence use within Quantum Mechanics (Baumgratz et al., 2014)

Details are available in the referenced literature.

RESEARCH DESIGN

Research Methodology

For the earlier design of the GEA theory and their artefacts the research methodology Design Science (DSRM) of Hevner et al (2004) and Wieringa (2015), including the design science research methodology process (DSRM process) of Peffers et al (2012) has been followed. Also, artefact evaluation based on Gregor et al's anatomy of a design theory (2007) has been used. For the evaluation of theory and artefacts Yin (2013) has been applied. The fourth GEA artefact, the GEA-C-index - currently under development-, will use these same research methodologies, and so will the EC-index. We will formulate a research problem, that will lead to our research questions and a description of the artefact to develop, and use case study as a mean to strengthen both design and knowledge. The case studies in this paper can be interpreted as single case experiments under idealized conditions to aid in developing the artefact (cf Wieringa, 2015), with the primary goal to assess whether it is feasible to construct a meaningful quantification of enterprise coherence.

Problem Statement

The presumption is that in spite of the developments on enterprise coherence governance, enterprises still lack on coherence, and that measurement of enterprise coherence will strengthen the need for moving towards improved enterprise coherence governance, which in turn will promote transparency of decision-making, delivery of reasoned decisions, and respect for proportionality in decision-making. This will improve viability of organizations. Our problem statement is formulated as follows: *a generic metric that would allow to assess decisions, architectures, and even enterprises on their coherence is lacking*. Based on the principle 'what gets measured gets done', lack of measurement indicates that enterprise coherence gets overlooked within the average organization, which weakens governance.

Research Question

It is assumed that enterprise coherence governance leads to better enterprise coherence. However, to be able to demonstrate that relationship, measurement, and therefore quantification, of enterprise coherence is required. Our research question is therefore: *how to quantify enterprise coherence?* To that matter, the aim is to develop a GEA artefact, that measures enterprise coherence itself. We will call this additional artefact the EC-index.

Artefact

The EC-index is envisioned to take decisions and directions (as grounds for decision making) as input, and give enterprise coherence as output. The EC-index has a target group consisting of Enterprise Architects and Senior Management of organizations of over 750 employees, either national or international, commercial or not-for-profit, with a more permanent character. The context is formed by the aim to support (architectural) governance, by facilitating decision making to come to a more sustainable enterprise. Key requirements are that the calculation must adhere to an enterprise architecture definition of enterprise coherence, be relevant and representative in enterprises of the earlier described target group, and have added value in an enterprise dashboard. Furthermore, it must be end user friendly, both in format and (re)calculation, must be scalable and future proof, and data gathering for calculation must fit the enterprise practice. We will give our attention first to one single essential subcomponent: a coherence calculation engine. And for this calculation engine, focus of this paper is on the calculation model. Within this focus area the main knowledge question is if a consistent, practical, scalable method can be found to calculate (enterprise) coherence in line with the definition of enterprise coherence.

EXPERIMENTS

The *first case* is a historical case study. For a set of decisions on cloud implementations for a midsize (ca. 3000 employees) organization, a Project Start Architecture (PSA) has been drawn up with an architectural description. The scope is set to look only at the linkage between decisions on the one hand, and principles on the other hand. The case consists of 60 decisions, and 21 principles, which were already categorized in three subgroups. In this paper we shall call these categories 'Principles_Category_1', 'Principles_Category_2', and 'Principles_Category_3'.

The *second case* is an Epic Start Architecture (ESA) on a data oriented project, in which 27 principles were recognized, and 21 decisions. For two contradicting decisions the change in enterprise coherence is calculated. Aim for the experiment is to view how different decisions lead to different coherence calculation results. The principles were here in 5 different categories.

In *both cases*, decisions and principles construct a bipartite graph, where the relation between a decision and a principle represents to what extent the decision supports the principle. The graph can be represented as a matrix with decisions as rows, principles as columns, and their relationship as weight. For the case at hand weights are simply set to '0' (absence of a relationship: does not support) or '1' (presence of a relationship: does support). We calculate the coherence with the various selected methods, and compare methods on a number of aspects, as presented in Table 1.

Table 1 Aspects of coherence with respect to selected methods

Aspect (Y/N, n.s. = not studied)	TEC	LC	S_TEC	QM
Graph as underlying concept	Y	Y	Y	Y
Applicable to practical case	N	Y	Y	Y
Use of projection	n.s.	Y	Y	N
Use of directed coherence graph	n.s.	N	N	N
Use of normalization	n.s.	Y	Y	Y
Support of local coherence	n.s.	Y	Y	Y
Extensible to larger cases	n.s.	Y	n.s.	Y

Graph as underlying concept

All models have the graph as underlying concept. Because of the 'relational' nature of the concept of coherence this does not come as a surprise, yet it gives a strong pointer for the direction to look for a solution.

Applicable to practical case

Not all methods were equally suitable for application to the studied cases. TEC's calculation method leans on the use of positive and negative relationships and the practical cases lacked any negative relationship. We found it difficult to address this in a meaningful way. The other methods did allow a form of coherence calculation for the cases at hand.

Use of projection

For the LC method the adjacency matrix B for the bipartite network of decisions vs principles is mapped to a *projection* matrix A of decisions vs decisions. This can be done through the formula $(A)_{ij} = (BB^T)_{ij} - 2\delta_{ij}$, with δ_{ij} being the Kronecker delta (Thurner et al, 2018). We use these one-mode projections non-directed and the weighing is adapted to our specific purpose.

For the S_TEC method, an hierarchical model of decisions and principles has been setup. Then based on the position of the place of the interconnection in the hierarchy and the distance to the top of the hierarchy, the strength of the link between two different decisions has been calculated. This constitutes a new 'coherence graph' of decisions between themselves, that can be expressed as a new decision x decision matrix. Now, the S_TEC method constitutes in fact also a form of projection. It is even the case that dropping differences in weights turns both the LC as well as the S_TEC method into the same generalized projection model.

The QM based coherence only takes a square matrix as a basis for calculation. Clearly a bipartite graph is in general not square, so the only way to apply this method is to take the (square) projection matrix as starting point.

Use of directed coherence graph

Direction may be an important aspect of coherence. The LC method leaves room for the notion of direction in the bipartite decision x principle matrix. After projection the notion of direction in the decision x decision matrix however disappears. Likewise, the construction of the hierarchy in the S_TEC method can be regarded as a directed graph. In the resulting coherence graph however, also here this directional aspect is lost. As said, the QM method already takes the projection method as a basis, therefore also expresses no direction in its graph.

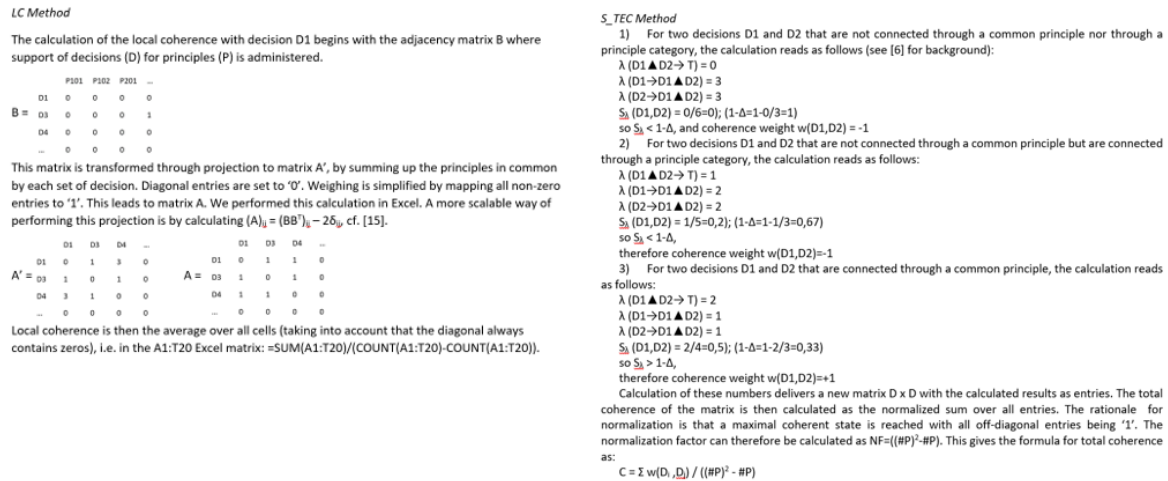
Use of normalization

Normalization can be useful in scaling and comparing different cases. In the cases at hand, normalization is performed by taking the average over all entries in the decision x decision projection matrix. However, since the diagonal entries are set to zero in this matrix per definition, we need to correct for this, which is done by dividing the sum of all matrix cells by a factor $((\#decisions)^2 - \#decisions)$.

Support of local coherence

LC, S_TEC, and QM can all be used to calculate local coherence for the cases at hand, i.e. it allows to calculate coherence for varying sets of decisions and principles (see Figure 1 for examples). E.g. for the *second case*, local coherence is calculated where the choice of one decision (D1) leads to another projection matrix than for another decision D2. The difference in coherence between D1 and D2 becomes EC = 0.426 if decision D1 is taken, and EC=0.436 if decision D2 is taken. This implies that decision D2 contributes more to coherence than decision D1. Based on local coherence arguments only, the decision D2 is preferred. For the *first case*, local coherence over the unweighed decision network can be calculated to be EC = 0,28.

Figure 1. Examples coherence calculation conform LC method and S_TEC method.



Extensible to larger cases

Local behavior can be extended to larger scales, and normalization ensures that the numbers are independent of scale, for both the LC method and the QM method. The S_TEC method calculations become more complex when the hierarchical network is expanded to include more layers. It has not been part of this study to validate scaling for this matter.

CONCLUSIONS

There seems to be consistency among the calculation models, even though they are from domains that can be considered far apart. All of them are graph based, and all methods relevant for the cases are projection based, non-directed, and calculate coherence locally. This supports the idea that a consistent method to calculate (enterprise) coherence can be established. Especially the LC method scales well and is relatively easy to explain and calculate. All methods are in line with the definition for enterprise coherence as defined in GEA. It is shown that differences in decision making result in different local coherence values, which could form part of the power of coherence calculation. This paper gave plausibility to the selection of candidate methods, assessed the methods on a number of aspects, and showed their working in two practical cases. By doing so support is obtained for the idea that a graph based enterprise coherence calculation engine can be designed to work in practice and be beneficial as well. This study was able to show a plausible, practical, yet non-existing way to calculate coherence for enterprise decisions.

FURTHER STUDY

A systemic literature research will be needed to exclude other calculation methods, and ensure that the used method is indeed the most suitable. Weighing factors should be investigated further, e.g. how weighing should express how much a decision contributes to a certain direction. Also, aggregation requires further study, e.g. how to aggregate decisions vs principles with decisions vs e.g. goals. Finally, other parts of the EC-index artefact, e.g. GUI, interfacing, access, need to be researched further.

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Student Perception on Entrepreneurship Program Learning: Insights from GUESSS

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Abstract

Entrepreneurship education is essential for the development of entrepreneurial skills and an entrepreneurial mindset among tertiary students. Universities, all over the world nowadays, offer entrepreneurship courses (compulsory or elective) and other educational offerings. Research findings regarding the impact of these offerings on student entrepreneurship though, are inconsistent, as some researchers report positive results, whereas others report even negative effects. Additionally, the share of nascent and active entrepreneurs remains relatively low among tertiary students, and only a small share of students would like to become entrepreneurs directly after their studies. The aim of this paper is to examine students' perceptions on program learning as an indicator of entrepreneurship courses effectiveness, in different groups of students (active, nascent, dreamers and abstainers) and identify those that benefit the most out of offerings. For this purpose, a sample from the "Global University Entrepreneurial Spirit Students' Survey" (GUESSS 2018) is used, including participants from 50 countries. According to the results, active, nascent and intentional entrepreneurs (dreamers) have greater benefit from university offerings, than non-intentional entrepreneurs (abstainers). Also, those choosing the founder career option on the long term seem to have a greater benefit, compared to those choosing a career as a founder right after studies. Moreover, compulsory courses as part of student studies seem to have more benefit than elective courses. Finally, differences are observed between business and engineering students.

KEYWORDS

Entrepreneurship education, Career choice, GUESSS, Program learning, Students.

INTRODUCTION

Entrepreneurial career choice is largely determined by one's entrepreneurial mindset, which is developed under the influential factors of the economic and social environment (Kirby and Ibrahim, 2011). Entrepreneurship education is essential for the development of the entrepreneurial mindset of students and therefore it attracts research interest in the relevant literature. As a result, most universities offer compulsory or elective entrepreneurship courses, and an increasing number of students from almost any discipline strive to attend at least one of them (Kakouris and Liargovas, 2020). Attempts to instill the entrepreneurial mindset are also occurring in lower educational levels (Likar et al., 2015). However, the effect of entrepreneurial courses on student entrepreneurship shows inconsistencies (Dinis et al., 2013). Some studies for example, show that the attendance of these courses has no significant effect on students' career choice in favor of the entrepreneurial career option (Marques et al., 2012; Medeiros et al., 2018; do Paço et al., 2013; Sitaridis and Kitsios, 2017). These findings are consistent with those of the Global University Entrepreneurial Spirit Students' Survey (GUESSS), showing that the great majority of students prefer to be employed in firms, or in academia, rather than to follow an entrepreneurial career (Holiienka et al., 2017; Sarri and Laspita, 2016). Additionally, the share of nascent and active entrepreneurs among tertiary students remains insufficiently low, and only a small share of those already involved in entrepreneurial activity, explicitly declare a clear preference towards the option to be founders by the end of their studies (Kakouris, 2016; Law and Breznik, 2017; Maresch et al., 2016).

Students' perception of program learning is an indicator of entrepreneurship course effectiveness (Souitaris et al., 2007). The perceptions of students about courses have been used for course evaluation (Sitaridis and Kitsios, 2019a) and can offer a tool to evaluate their beliefs regarding the development of abilities and skills during the courses and other university offerings. Comparing the perceptions of different demographic groups, can indicate groups that benefit the most out of courses, and highlight inefficiencies.

One important factor about students' perceptions of program learning regarding entrepreneurship courses, is previous entrepreneurial experience. Some authors claim that students predisposed to entrepreneurship, such as successors of a parental or other firm have an advantage over other students, since they are more motivated (Fellnhofer, 2017). Others claim that students with a prior experience with entrepreneurship, such as nascent or active entrepreneurs, benefit the most. Another influential factor, which seems to differentiate the impact of courses on students'

perceptions, is the type of course (elective or compulsory). Some authors conclude that elective courses do not make an impact because students that select them are already exposed to entrepreneurship, so they are already confident about their entrepreneurial aptitude. Another important finding is that students attending courses in business departments often exhibit a reduced inclination towards entrepreneurship, compared to those from other departments (Franke & Lüthje, 2004; Kakouris, 2016; Law & Breznik, 2017; Maresch et al., 2016; Passoni & Glavam, 2018). Although, most of the participating students in GUESSS 2016, declared a positive learning benefit from the courses they had attended on average (Sarri and Laspita, 2016), not all students declare a certain benefit from and significant differences are observed.

The objective of this paper is to examine the relation between the perceived learning and the anticipated student career option, using data derived from the 2018 GUESSS survey. An effort to highlight the critical differences among different types of student groups is made, using descriptive statistics and correlation analysis.

The structure of the paper is as follows. In the next section the methodology of the study is presented, followed by the discussion section and conclusions. Finally, the limitations of the study are discussed and suggestions for future research are given.

METHODOLOGY

In order to examine the effect of students' perception on program learning, a large sample derived from the 2018 Global University Entrepreneurial Spirit Students' Survey (GUESSS) survey was used. GUESSS is an international research project that focuses on the entrepreneurial intentions and activities of university students across many countries. The objectives of GUESSS are the observation and evaluation of university activities, using measures for program learning and university environment (Sarri and Laspita, 2016).

The sample included N=187492 students from 50 countries, with no missing data on the items of interest. Countries with less than 100 responses were removed from the sample. Following the methodology of Holienka et al., (2017) and Kakouris, (2016), calculated entrepreneurial intention factor scores were used to distinguish the latent entrepreneurs (dreamers) from the abstainers towards entrepreneurship among the respondents. A factor analysis was conducted using the questionnaire items for Entrepreneurial Intention (EI) and Program Learning (PL), following the suggestions of Distefano and Míndril, (2009). The analysis produced exactly 2 factors, with a total amount of variance explained up to 75.6%. All items demonstrated adequate communalities and factor loadings on the theoretically corresponding factor. The KMO test (0.86) and the significance of the Bartlett's test of sphericity ($\Delta\chi^2=747573.6$, sig<0.001) indicated sampling adequacy of data. As evidenced by Cronbach's Alpha coefficient values, both greater than 0.9, the two factors demonstrated excellent reliability. The results of the factor analysis are summarized in Table 1.

Table 1

	Questionnaire item	Communalities		Factor Loadings		Factor Reliability
		Initial	Extraction	EI	PL	
Program Learning (PL)	Q3.2_1	.644	.685		.816	.926
	Q3.2_2	.756	.805		.889	
	Q3.2_3	.745	.810		.892	
	Q3.2_4	.609	.560		.765	
	Q3.2_5	.670	.647		.804	
Entrepreneurial Intention (EI)	Q4.1.1_1	.658	.624	.742		.960
	Q4.1.1_2	.800	.789	.877		
	Q4.1.1_3	.828	.840	.909		
	Q4.1.1_4	.859	.894	.958		
	Q4.1.1_5	.782	.795	.902		
	Q4.1.1_6	.848	.866	.950		
Extraction Method: Maximum Likelihood.				Cronbach's Alpha		

Dummy variables were created for nascent and active entrepreneurs, using two special GUESSS questionnaire items for this purpose, asking directly the respondents whether are they currently trying to start their own business, for nascent entrepreneurs, or are they already running their own business, for active entrepreneurs. Next, z-scores were calculated for PL and EI, in order to create dummy variables for Dreamer entrepreneurs and Abstainers. Those with EI z-score greater or equal to zero were designated as Dreamers, whereas, those with EI z-score less than 0, were designated as Abstainers respectively. According to the descriptive statistics presented in Table 2, a small share of students are active entrepreneurs (11.6%), whereas a higher share of students are nascent entrepreneurs (19%). Larger numbers of

students declare to be dreamers (34.9%) and abstainers (34.5%). Regarding the choice to establish a firm, the larger share of students declared their intention to become founders 5 years after studies (35.1%) (Founder 5YAS), whereas a relatively small share of students declared their intention to be founders right after studies (8.7%) (Founder RAS). Moreover, 30% of students were attending Business or related schools, 24% were attending engineering schools, whereas 37.5% had self employed parents. Regarding the two genders, both males and females are equally dreaming an entrepreneurial career in terms of intentions, with 34.8% and 35% respectively. However, the picture is totally different when the shares of active and nascent entrepreneurs are examined, with the share of female active entrepreneurs (8%) being exactly half the share of males (16%) and the share of nascent female entrepreneurs (16.9%) being smaller than that of males (21.6%). Moreover, the share of female abstainers is increased (40.1%) compared to the share of male abstainers (27.6%). Finally, the comparison between business and engineering students did not highlight any significant differences. However, business students seem to be more familiar with the entrepreneurial career option, since the shares of active and founder after studies categories demonstrate a minor prevalence compared to the shares of engineering students.

Table 2

	Descriptive statistics						
	All	Active	Nascent	Dreamer	Abstainer	Founder RAS	Founder 5YAS
All	-	11.6	19.0	34.9	34.5	8.7	35.1
Male	44.4	16.0	21.6	34.8	27.6	10.8	37.4
Female	55.6	8.0	16.9	35	40.1	7.0	33.4
Founder RAS	8.7	33.7	40.6	23.5	2.2	-	-
Founder 5YAS	35.1	13.1	32.2	47.9	6.8	-	-
Business	30.0	12.9	21.7	39.0	26.4	11.6	43.3
Engineering	23.6	10.7	21.0	39.2	29.2	8.1	40.8
Self Employed Parent	37.5	16.9	22.4	35.4	25.3	11.0	39.6
16-25	76.5	9.5	18.6	36.1	35.8	7.1	34.9
26-35	15.8	18.0	20.5	30.9	30.6	12.0	36.2
36-45	3.8	23.6	21.2	29.0	26.6	19.8	37.0
46-55	1.3	23.4	20.8	25.9	30.0	22.5	34.3
56+	0.3	34.6	19.3	22.8	23.3	28.2	33.7

A correlation analysis was conducted for the examination of Program Learning (PL) relation with dummy variables of each group. Active entrepreneurs and Dreamers declare that they gained the greatest benefit from university courses and offerings they have attended, $r=.143^{**}$ and $r=.157^{**}$ respectively. Nascent entrepreneurs declare a somewhat weaker benefit from their courses $r=.092^{**}$, whereas Abstainers declared a negative experience from their courses $r=-.329^{**}$. Moreover, PL demonstrated a higher correlation with those students who declared their intention to be founders 5 years after their studies $r=.116^{**}$, than those who declared their intention to be founders right after studies $r=.090^{**}$. Finally, elective courses seem to be more positively related $r=.189^{**}$ to program learning compared to other options, based on the perceptions of students. Of course, it is very natural for those that chose an elective course to be more willing to participate and demonstrate a higher interest, however the measure of correlation itself is not what one would consider a smash hit. On the other hand, program learning had a strong and negative correlation with those attended no courses, as expected.

CONCLUSIONS

The GUESS initiative is a very promising platform for entrepreneurship researcher interested in student entrepreneurship and career intentions. The number of studies is gradually increasing, however, the need for the research to be adopted by as many as possible tertiary institutions is evident from the disparities in the numbers of participants in different countries. The claims of previous studies about the limited number of nascent and active entrepreneurs among students are confirmed. Moreover, although the number of students who want to become founders 5 years after their studies is relatively increased (35.1%), the share of those who want be founders right after studies, remains low (8.7%) (Kakouris, 2016; Law and Breznik, 2017; Maresch et al., 2016). Contrary to previous research (Franke & Lüthje, 2004; Kakouris, 2016; Law & Breznik, 2017; Maresch et al., 2016; Passoni & Glavam, 2018), the present study shows that business students are more inclined to entrepreneurship, at least compared to their colleagues from engineering. Finally, differences are observed in program learning between students of different course types are present, but not critical. This means that additional factors regarding course design must be taken in account (Sitaridis and Kitsios, 2015, 2018, 2019b) to improve effectiveness. Innovative ways of cultivating entrepreneurial intentions, such

as hackathons (Kitsios and Kamariotou, 2017, 2018) and innovation competitions (Sitaridis and Kitsios, 2017) should be adopted.

The results of this study offer educators and scholars valuable insights on the impact of entrepreneurship education program learning, based on information derived from a huge student data set. Future research can examine the causes behind the differences.

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Computer Self-Efficacy as an Antecedent of Entrepreneurial Intention

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Abstract

The evolution of Information Technology has undoubtedly made a significant contribution to many entrepreneurial success stories in the last decades. Computer Self-Efficacy is an IT specific measure of the general ability to use computers and software and its relation to entrepreneurial intention, a valid precursor of entrepreneurial behavior, consists an interesting topic which recently came into focus of entrepreneurship research. In this empirical research conducted among secondary education students, the efficacy of autonomous use of computer software is highlighted as an influential factor for the entrepreneurial intentions of students. Autonomous use of computer software incorporates increased learning motivation, risk undertaking and openness to new experiences, which are essential for entrepreneurship. The findings have useful implications both for instructors and software designers.

KEYWORDS

Entrepreneurial intentions, Computer self-efficacy, Students.

INTRODUCTION

Many revolutionary emerging technologies, like cloud computing, virtual reality and the internet of things, are without doubt based on the evolution of Information Technology and the groundbreaking conceptions of some talented entrepreneurs. The entrepreneurial characteristics like creative problem solving, innovativeness and self-efficacy are considered crucial for the manifestation of entrepreneurial behavior (Joensuu-Salo et al., 2015), and technology innovation is considered one of the driving forces of entrepreneurship (Dutta et al., 2015; Guzman et al., 2016). As a consequence, technology acceptance of entrepreneurs is frequently examined by entrepreneurship research (Moghavvemi et al., 2016). However, the relationship between entrepreneurship and individual IT competency has only recently come in the foreground of relevant research (L. Chen, 2014). Computer related factors such as increased programming skills, on the other hand, are positively related to students' generalized self-efficacy (Ramalingam et al., 2004). Self-Efficacy is the personal belief about the ability to exercise one particular behavior and has been associated to entrepreneurial intention (Boyd & Vozikis, 1994; C. Chen et al., 1998). Computer Self Efficacy (CSE) is an Information Technology (IT) specific individual characteristic and refers to the personal ability to use computer software (Compeau & Higgins, 1995), and the ease or difficulty one has in learning the required skills (Marakas et al., 1998). The relation between entrepreneurial intention (Bird, 1988; Krueger & Carsrud, 1993), a valid precursor of entrepreneurial behavior (Dyer et al., 2008; Krueger, 2009), and CSE is examined, as it is an interesting topic of entrepreneurship research (L. Chen, 2014; C. M. Chou et al., 2017; C. M. Chou et al., 2011).

The research is conducted among secondary education students, and the relations between CSE and entrepreneurial intention and its antecedents derived from the Theory of Planned Behavior, are examined, using a cross sectional questionnaire.

THEORETICAL BACKGROUND

Entrepreneurial Intention

Intention is defined as a state of mind orientating an individual's attention towards a specific goal (Bird, 1988). Theoretical models based on intentions were successfully used for the prediction of various behaviors based on intentional behavior theories (Ajzen, 1991; Ajzen et al., 2009; Fishbein & Ajzen, 1975). Entrepreneurial intention (EI) is the state of mind in which the individual is seriously planning the involvement into an entrepreneurial activity. EI was successfully used for the prediction of actual involvement with entrepreneurship (Krueger et al., 2000). According to the Theory of Planned Behavior (TPB), there are three antecedents of intention, namely Personal Attitude (PA), Perceived Behavioral Control

(PBC) and Social Norm (SN), which have been successfully used as EI predictors by recent research in the IT field (Sitaridis & Kitsios, 2017).

Computer Self-Efficacy

Computer skills and IT competencies, are integral part of the contemporary entrepreneurial practice, since they underpin digital opportunity awareness (Sambamurthy et al., 2003). Moreover, generalized CSE has a positive effect on the intention of future computer use, and it is also considered a required skill for starting-up both IT related businesses and non-IT related businesses (L. Chen, 2014). Consequently, increased CSE should have a positive effect on the entrepreneurial aspirations of students. CSE is an IT specific individual trait, derived from Self-Efficacy (Bandura, 1986), that refers to the personal perception, regarding the ability to perform certain computer tasks. CSE is task oriented (Marakas et al., 1998), however it is possible to be examined in a broader sense, denoting the general ability to use a computer (Compeau & Higgins, 1995). The higher the level of CSE, the higher the expectancy for someone to successfully perform specific computer tasks and the lower the need for assistance in order to accomplish them. A positive relation between CSE and Entrepreneurial Self-efficacy was found (L. Chen, 2013), which in turn was a major predictor of entrepreneurial intention. One limitation of the mentioned study is examining only IT related business intentions. Other researchers examining the effect of CSE and computer anxiety on entrepreneurial intention implied a positive influence between CSE and EI (Albashrawi & Alashoor, 2017). However, some ambiguity exists regarding the effects of CSE due to the differences observed depending on the software package of reference (Agarwal et al., 2000).

METHODOLOGY

In order to examine the impact of computer self efficacy on students' entrepreneurial aspirations, we utilized measures from the existent literature. A cross sectional questionnaire was used, in order to examine the direct effects of CSE on EI and the three antecedents, according to (Ajzen, 1991). For the CSE measures the questionnaire used 5 items from (Compeau & Higgins, 1995). These items examined the ability of the individual to use an application on the computer or mobile device with some form of assistance or with no assistance at all. For the measurement of the TPB derived constructs the questionnaire used items from (Liñán & Chen, 2009; Sitaridis & Kitsios, 2017). More specifically, 4 items were used for the measurement of EI, 4 items for PBC, 4 items for PA and 3 items for SN. All items were answered in a 5 point Likert scale between 1="completely disagree" and 5="fully agree". The questionnaire was administered to secondary education students, during the school year of 2017-2018. The data were factor analyzed in order to find latent variables. The relations between constructs were examined with correlation analysis.

Sample

The sample consisted of 291 students of secondary education 140 (48.1%) of which were males and 151 (51.9%) females, 79.7% coming from the general education, while the rest (20.3%) were attending vocational schools.

Factor analysis and the resulting constructs

In order to highlight the relations between latent variables, the data were factor analyzed using SPSS. As a result, six (6) factors were attained, representing the 5 constructs of the conceptual model. According to the items' loadings, these factors represent EI, PA, PBC, SN and two separate factors for CSE. The first factor, CSEaut represents the autonomous dimension of CSE, while the second factor CSEass represents the assisted dimension of CSE. All factors are significant since all the loadings were above 0.5. All constructs exhibited adequate reliabilities, as evidence of good internal consistency (Hair et al., 2009). The results of the factor analysis are presented in Table 1.

Table 1. Factor analysis

Items	Components					
	INT	SN	PBC	PA	CSEaut	CSEass
int4	.922					
int3	.890					
int1	.871					
int2	.855					
sn2		.885				
sn3		.869				
sn1		.834				
pb1			.897			
pb2			.840			
pb3			.711			

att3						.929
att4						.786
att2						.646
cse1					.940	
cse2					.911	
cse4						.871
cse3						.834
Cronbach's Alpha	0.92	0.83	0.78	0.838	0.836	0.70

Analysis of Correlation

According to existing research, a positive relation was expected between CSE and EI constructs. However, only a weak positive correlation ($r=0.13$, $p=0.01$) was found between EI and CSEaut. This means that there is a positive effect of the autonomous CSE on EI of students. Additionally, the Autonomous CSE was positively correlated to all the three antecedents of EI, i.e PA ($r=0.20$, $p=0.01$), PBC ($r=0.16$, $p=0.01$) and the SN ($r=0.20$, $p=0.01$). Assisted CSE, on the other hand, had no statistical significant correlation with the TPB constructs, with an exception to the weak positive effect on PA ($r=0.12$, $p=0.05$). Finally, the three antecedents of EI, were strongly correlated to EI, and in the expected direction, according to TPB. The Social Norm had the weakest correlation coefficient.

Structural Equation Modelling

The causal effects between constructs were examined using structural equation models (SEM), using EI as an outcome and CSEAut, CSEAss, PBC, PA and SN variables as predictors in a confirmatory factor analysis conducted for causality testing.

The fit statistics for the model, were appropriate (RMSEA=0.05; CFI=0.97; GFI=0.93; CMIN/df=1.73; SRMR=0.08; PCLOSE=0.99). (Hu & Bentler, 1999). Based on the regression weights observed, both CSE contracts had no statistically significant direct effect on EI. Contrary though, CSEAut exhibited a positive statistically significant effect on all three TPB constructs, whereas CSEAss had no statistically significant influence, as evidenced by the standardized regression weights.

RESULTS

CSE is measuring the ability of students to use a software application, either on the computer or a mobile device. The influence of CSE on students entrepreneurial intention was examined. The construct was separated into two distinct factors, representing autonomous and assisted computer software use. Only the autonomous factor CSEAut proved to have a positive direct correlation to EI. Additionally, the autonomous CSEAut had a positive causal effect on all the three antecedents of the Entrepreneurial Intention, whereas assisted CSEAss did not have any significant contribution. This finding is important both for entrepreneurship and IT education, since independence in the use of computer software implies ability to improvise, increased self learning skills, risk handling and openness to new experiences, which are essential for the development of entrepreneurial personality. The absence of direct effect between CSE and EI show the loose connection between computer related knowledge and entrepreneurial mentality in the secondary education curriculum. Therefore it is essential for IT instructors to combine IT knowledge with entrepreneurial knowledge, and to highlight the contribution of IT in entrepreneurial success stories with the use of appropriate examples. Moreover, the findings have implications for software designers in order to provide learners with successful experiences which will increase their autonomy in computer use and as a consequence support entrepreneurial thinking through independence, risk undertaking and self-learning motivation. The findings also imply the existence of an indirect effect of CSE on EI, through the three antecedents of intention.

CONCLUSIONS

IT is the cornerstone of innovation and entrepreneurship (Sambamurthy et al., 2003). In this research, the autonomous dimension of CSE was highlighted. The fact that, the students with an increased autonomous CSE, have an increased EI, denotes an increased awareness of the opportunities offered by entrepreneurship. These students are not satisfied just following steps in the scenarios provided by the teachers but they usually improvise with pleasure. Therefore, it is essential for students to develop their CSE, and especially autonomous CSE, since this can nurture their entrepreneurial aspirations. Autonomous CSE can improve students' awareness of digital options offered by Information Technology. The moderate positive influence of CSE on EI, may indicate the missing connection between IT and entrepreneurship education. In this direction, teachers should insist on the contribution of IT in entrepreneurial activity using the

appropriate examples from successful entrepreneurial successes. Additionally, software learning courses should promote autonomy and improvisation through the utilization of explorative and playful approaches such as experiential learning and problem solving. Educational software designers on the other hand, should include playful features in software in order to assist autonomous CSE. The results of this research are based on a limited sample, but are promising for future research. In order to generalize the findings of this work, the CSE constructs should be extended with more items, and bigger samples should be employed.

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Session 29: OR and Covid-19
chair: Jason Papathanasiou

Strategic management in the season of Covid 19. Case studies from the region of Thessaly.

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Abstract

The appearance of Covid-19 and its rapid spread created new data in the structure, organization and operation of many businesses. Many of them were forced to suspend their operations temporarily, others were forced to underperform, and there were those who suspended their operations permanently. The above conditions created new forms of work such as teleworking. Electronics stores have quickly adapted to the new requirements in an effort to meet their customers' ongoing needs. The proposal will approach case studies from major electrical appliance stores operating in Greece and in particular in Thessaly. Data collection will be used through an interview and a secondary sources study. An extensive report will first be made on the new data that emerged due to the pandemic, and then the ways in which these companies have dealt with and adapted to the new situation will be reported. The aim is to present the future situation and the changes that will take place in the management of human resources with the use of technical science. The findings are expected to help inform business executives so that they can operate more securely and more efficiently in the new management system. In the same way, companies will be able to better organize the current situation and face any difficulties that arise.

KEYWORDS

Technology, Teleworking, Business Environment, Covid-19, Thessaly.

INTRODUCTION

Covid-19 describes an unexpected event that could not be predicted and has a great impact on society. Businesses in particular have borne the responsibility of their safe operation, while maintaining the necessary safeguards to protect their employees and customers. Safety, hygiene, human working conditions, productivity incentives, educational initiatives, human resources management are part of Corporate Social Responsibility actions of the companies (Aspridis et al., 2014). In the midst of all this, the world adaptability becomes very important. Every business, large or small, regardless of size, must adapt to the new data and to a new normality as it appears. Business leaders are gradually beginning to discern new consumer attitudes and give priority to new ways companies operate. This attitude leads to new behaviors and new approaches. Gradually new influences, new distribution channels and new ways of communication appear. These new models are important to be read and evaluated correctly by business executives, so that there is a slight adjustment to the new conditions (https://www.huffingtonpost.gr/entry/adapt-to-thrive_gr_5e958b8bc5b6c5b3d6b0adca_available_14-06-2020). In this context, the executives of the companies operating in Thessaly will be interviewed so that there is an update of the new data created in the market. The purpose of the article is to record through the interview process the business executives' views regarding the companies operation during the pandemic while at the same time recommendations are made to improve their operation. The aim of the work will also be to investigate the changes that occurred in the companies operation during the pandemic and to examine the transience or permanence of the changes that occurred.

RESEARCH METHODOLOGY

The research was conducted through the qualitative method and used the methodological tool of the semi-structured interview. The qualitative method is suitable for small field research, where research hypotheses have not been adequately analyzed by the scientific community (Adler et al., 2018; Bryman, 2008). This method allows an in-depth

process analysis. In an effort to understand this issue, the qualitative research allows us to be aware of the changes that have taken place (Babie, 2018). The research is small-scale due to lack of resources. Semi-structured interviews were conducted, lasting 10 minutes. The participants were electronics stores executives operating in the region of Thessaly. These executives were asked to answer six questions, namely: "What are the consequences of working remotely in your life?", "What are the psychological consequences of the new work experience?", "Present the advantages and disadvantages of the new way of employment", "What are the biggest problems you have encountered?", "Submit proposals for tackling the pandemic" and last, "What are the psychological consequences of the pandemic and the new reality?" At the end of the interview, they could also state anything else they considered necessary. During the interview, the necessary clarifications were given by the researcher. The interview can contribute to a meaningful dialogue and depends to a large extent on the researcher's perception. When the researcher is perceptive, they help the respondent to express themselves freely and to elaborate more on what they are saying (Adler et al., 2018; Babie, 2018). The results of the research are indicative and in no way do they represent the views and perceptions of all business executives in the area. It is worth noting that all data and responses submitted were used exclusively for this research.

Market influence factors

Adapting to the new conditions will not be easy and requires a different viewpoint of the new data and a renewed understanding of the situation with the adoption of a new strategy. The initial concern is to overcome the initial employees' and businesses' fear so that the new situation can be faced calmly. At this stage, care is primarily required for survival but also for maintaining the business operation. In order for this to happen, it is necessary that composure should be retained and the new data be read with a clear mind. At this point, it is important to take into account the younger generations who will be the potential future customers. These generations have grown up surrounded by new technological advances and are certainly more familiar with new technological tools (https://www.huffingtonpost.gr/entry/adapt-to-thrive_gr_5e958b8bc5b6c5b3d6b0adca_available_14-06-2020).

Another factor that needs to be taken seriously is the middle class. Globally, experts estimate that in 2020 half of the world's population will belong to the middle class for the first time, while by 2030 the middle class is expected to exceed five billion people worldwide, indicating that the middle class will be the largest purchasing power.

It is therefore prudent to plan ahead after the pandemic to consider the above new data. Each business can create its own processing and data collection system. However, businesses now have to try to think like customers, trying to figure out what customers would want in the future. Because the future will determine what will follow in the coming months and will identify many changes in the consumers' behavior and priorities. At this point the concept of adaptability is defined. Therefore, the triptych is now initially adaptability, then sustainable development and in the end, the digital change and the transition to the new era.

The great bifurcation that will result from the accelerated growth of technology and which is mainly based on artificial intelligence, machine learning and data analysis will reward those who anticipated in time and adapted to the development phase at the appropriate time (https://www.huffingtonpost.gr/entry/adapt-to-thrive_gr_5e958b8bc5b6c5b3d6b0adca_available_14-06-2020).

Strategic Planning

Managing a project is one of the most important management tools in many businesses. Companies running project management plans are in a position to predict their future. In particular, project managers are able to identify the company's upcoming problems and prepare themselves in advance (Rehor and Vrchota, 2017). Strategic management represents the current direction of administration and management and applies to all types of companies including small and large enterprises (Rolínek et al., 2014). Strategic management is a process that aims to ensure a long-term prosperity of managed issues. Its condition is based on the project executives (management, owners, key interest groups) who define the strategic objectives and then a resource management strategy while taking into account the external factors (Rolínek et al., 2015).

At this point it is essential to identify the steps that each company must follow in order to formulate its strategy. Initially, companies need to understand the new emerging market situation. The main driving forces of a business strategic planning are the things that are happening now in its environment and the things that it estimates will happen in the future. These can be positive data, but they can also be negative. Thus, the first stage concerns the problems, challenges and future risks facing the company (https://www.medicalmanage.gr/available_15-06-2020).

The next stage concerns the vision. What is the company's vision for the next day? The vision is to determine the rest of the strategic process. The clearer and more convincing the vision of a company's future, the stronger its strategy will be. This vision should include clear goals, such as revenue targets, market share goals that every business wants to attract as well as other elements such as values, purpose, business culture. In any case, there must be a specific goal,

qualitative (necessary actions and benefits) and quantitative (investment costs and performance). This vision is the one that will determine the business development plan and all the moves should be analyzed aiming at the desired result. In this second step, in a timeline, the specific actions that need to be done, such as customer communication actions and new services should be recorded. This phase allows each employee's role towards each goal to be determined (<https://www.medicalmanage.gr/available 15-06-2020>).

The next step is to identify the difficulties and obstacles that may arise in order to adapt the strategy accordingly so as to overcome them. Then the resources available to the company are examined. Resources refer to the available capital, the human resources, the technology and know-how. Once the resources have been identified, the company's strategy develops. That is, a path is created around the obstacles that have been identified, in order to overcome and achieve the business goals. Having developed the strategic orientation, specific details, schedules and responsibilities are regulated. Then the strategy which concerns the action need to be done for the clients and the new services is followed. Finally, it is necessary to evaluate the final outcome of all actions, whether positive or negative, and to record all those reasons that led to the specific result (<https://www.medicalmanage.gr/available 15-06-2020>).

Case study and remote work

In the present work, a case study was carried out in e-commerce stores in the geographical region of Thessaly. From the material obtained from the companies' executives, it was found that all the companies have a satisfactory degree of hygiene and safety of the employees. It was also found that in trying to face the new reality, many companies have applied new digital technologies. New digital technologies can help speed up the process of creating additional skills and allow employees to develop new distance and training skills using e-learning systems or the use of virtual reality technologies to familiarize pilots with new tasks or installation plans. Augmented reality systems help staff receive training, advice and support from distant colleagues (<https://www.liberal.gr/economy/stratigiki-diacheirisis-paragogikis-monadas-stin-pandimia/300012>, available 15-06-2020).

Regarding the new situation, in order to minimize the risk of a whole group of bosses or department heads entering a quarantine at the same time, the executives who are considered necessary to stay in the workplace can be divided into at least two sub-groups, without any physical contact. As they reshape their operations to keep employees safe and responsive to changes in the wider value chain, companies seek to maintain their performance at a high level and must evaluate every possibility by applying the most effective one. This is sometimes achieved at the expense of other important parameters of competition such as cost, time and product quality. Physical distance and work distances will make these standard approaches even more difficult, forcing companies to find new ways to manage the performance of their units (<https://www.liberal.gr/economy/stratigiki-diacheirisis-paragogikis-monadas-stin-pandimia/300012>, available 15-06-2020).

The pandemic will have long-lasting - perhaps permanent - effects on businesses, forcing them to restructure their activities to maintain production levels while protecting their employees. The next few periods will prove to be extremely difficult for the administrations and the executives of the companies. At the same time, the crisis creates opportunities to re-evaluate the way businesses operate and identify potential weaknesses that will be possible to improve in the future. By accelerating the adoption of new digital technologies and drawing on the flexibility and creativity of their staff, companies have the potential to emerge from the crisis in a way of operating more safely, more productively and more efficiently (<https://www.liberal.gr/economy/stratigiki-diacheirisis-paragogikis-monadas-stin-pandimia/300012>, available 15-06-2020).

Regardless of how a company operates, an important part of management is managing the human factor. The smooth operation of the staff contributes to the workforce improvement and business efficiency (Mullins, 1995). Every business needs to have a human resource management department. However, in smaller businesses, the staff management is usually done by the executives (Harris, 2000). Therefore, the actions of human resource management occupy an important place in creating sustainable competition (Langbert, 2000).

This highlights the importance of coordinating the various activities. Coordination refers to the way in which all the business' actions are related to each other. Of course, in order for all the planned work to be done properly, it is necessary to have regular communication between the groups of all departments. In addition, it is deemed necessary to have a proper division of responsibilities. Through division, responsibilities are shared among all executives, but they can often create tensions (Rutherford, 1999).

It is important to make use of staff in such a way as to ensure the production and distribution of goods and services in the markets, to maintain harmonious relations between individuals and groups, and to satisfy all employees' and the business' interests. Human resource management is the stage that leads to the smooth operation of a company's administrative functions (Beardwell and Holden 1994).

Nowadays, due to the rapid development of technology, the content of the job is constantly changing and changing. As a result, there is a constant need to redesign and analyze all jobs to make the necessary adjustments. All of the above

make job analysis one of the most important techniques that improves a company's organizational behavior (Katou, Budhwar, 2007).

The job description or Job Description defines the job title and provides detailed information about the relationship, the overall purpose, the primary tasks and the main occupations of the position. More specifically, the description of the position provides important information such as (Reynolds, Namasivayam, 2006):

The reason for the existence of the position and the expected results of this position.

The extent of the work, the functions to be performed and the tasks that need to be performed.

The results produced by each employee. The criteria for job satisfaction. The level of responsibility and the degree of decision-making of each employee.

The relationships of each employee and the degree to which he participates in teamwork.

The special features of the position that motivate employees. The factors of development, evolution and acquisition of new skills.

The hygiene and safety conditions associated with the use of equipment. At the same time, the job description is necessary to determine exactly where the position belongs to the organization and to clarify the goals for both the employees of the position and the company in general (Deligianni, 2019)

CONCLUSIONS

The research is a first enquiring effort, which could develop into a wider nationwide research. The research is necessary to generalize to all companies in this sector and to be repeated in a larger sample of respondents on a regular basis even after the end of the pandemic. In any case, it is necessary to check the validity of the conclusions and the reliability of the results. The participants in the research underlined as the main concerns of the new era the lack of interpersonal contact (with their colleagues, customers, as well as suppliers), the quality of technology and last but not least, the psychological issues. The results of the research are indicative and in no way represent the views and perceptions of all business executives in the area.

The new data created by the pandemic are gradually leading to the businesses' transformation so that they are suitable for use in a digitally activated world. It is therefore essential that business leaders realize that they need to better understand, implement and lead the digital transformation in the workplace. This goes beyond the traditional way of thinking and sets aside outdated strategies in order to explain what steps need to be taken to make an organization truly flexible.

Nowadays it is important for companies to consider how to create a fast pace in the organization, remove unnecessary processes, install innovation, map motivational strategy and develop talent towards success. This requires clear guidelines so as to determine the pace and frequency of change, avoid old habits and reform the behaviors of a workforce to integrate digital transformation, achieve organizational flexibility, and ensure high performance (Abraham and Perkin, 2020).

Last, we find that most countries around the world are trying to support their economies by channeling large sums of money into the market to counter the pandemic. It is a common belief that additional tax breaks and tax and investment incentives are needed to enable to restart a country's economy both locally and nationally. Everyone must now realize that this crisis is an opportunity to turn the strategic advantage of proper management of the pandemic crisis into a more stable basis. For this to happen, real progress is needed, taking advantage of technology, innovation and digital transformation, so that the transition to the post-pandemic era will become smoother (<https://inbusinessnews.reporter.com.cy/financials/cyprus/article/245895/i-oikonomiki-pandimia-kai-o-dromos-pros-to-restart>, available 15-06-2020). At this time, the long-distance work that has come and will remain as a single part of the productive web and the businesses' operation in the post-pandemic era will now be an integral part.

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The Importance of Smart Eco-Social Villages in the Focus of Covid- 19 Pandemic

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Abstract

While human interacts with nature in order to sustain life, ecological crises such as rapid consumption of resources, inequalities among individuals, air pollution and climate change that cause disruption in the balance of the ecosystem are observed. "Covid-19", described as a biological disaster, an ecological and social crisis, is one of the important pandemics that continue to affect the world up to date. The mortality rates associated with Covid-19 are quite high compared to other pandemics in almost all parts of the world, being the elderly who are 65 years old and older with chronic diseases in the first place. Isolated life based on both contamination risk and quarantine practices has caused many physical, mental, social and economic problems, and adaptation to the new normal has become difficult. Thus, the ongoing destructive effects of this pandemic at both individual and local levels have increased the need for smart eco-social villages as sustainable alternative living spaces. These villages, which focus on sustainable rural development, consider digitalization as a facilitating tool in agricultural production activities. It is grounded on innovative services based on advanced technologies in rural development, and focuses on the development of rural infrastructure and strengthening local communities on the basis of participation, inclusion and democracy in the light of the local culture and environmental centered approach. The main objective of this study is to explain the importance of smart eco-social villages in rural areas in the focus of the Covid-19 pandemic. Thus, the importance of smart eco-social villages for sustainable rural development is explained by evaluating the impacts of Covid-19 on the rural areas.

KEYWORDS

Covid 19, Rural development, Sustainability, Smart eco-social village.

INTRODUCTION

The Covid-19 pandemic has left almost every country facing crises, particularly health and the economy. As of July 2020, the number of cases in the world is over 10 million and the number of individuals who died due to the pandemic has exceeded 516 thousand (WHO, 2020a).

The Covid-19 pandemic has negatively affected individuals at micro level, families and groups at mezzo level, and communities and countries at macro level. In this pandemic process, psychosocial risk factors such as mourning, loss, unemployment, homelessness, deterioration of relationships, etc., which negatively affect the well-being of individuals and their families emerged (Holmes et al., 2020).

In addition, problems have been experienced in many areas such as education, health, economy, and working life in various countries (WHO, 2020b). Some of these problems are the decrease in employment and therefore the increase in unemployment, unregistered employment, economic difficulties and social security problems during the pandemic period (ILO, 2020). These problems have also caused fear, anxiety and stress (Bao et al., 2020; Rajkumar, 2020).

As a precautionary measure, quarantine practices have been initiated, formal education has been suspended, and changes and transformations have occurred in the field of work. These practices affected daily living routines such as meeting the basic needs of individuals living in both rural and urban areas, their access to services and restricting their social relationships (Sharma et al., 2020). This process, which emerged with the Covid-19 pandemic, has been experienced in different ways depending on the living conditions of individuals living in rural and urban areas. Particularly in rural areas, inadequacy in health services, limited access to online education and problems related to telecommunications were felt intensively in this process. Meanwhile, those living in this area have been affected by the psychological atmosphere that the Covid-19 pandemic has created. On the other hand, the effects of this pandemic contributed to bringing many innovations in terms of economic, political, social, legal and cultural aspects to the agenda of the rural area. The adequacy of public services in rural areas and current rural-urban inequalities have begun to be discussed in a different dimension (Summers-Gabr, 2020). Because incapacities, especially in the infrastructure of health

and technology systems, have negatively affected the health and welfare levels of individuals by causing existing infrastructure problems in rural areas to deepen as well as the risk of being isolated from social life to come forth (Henning-Smith, 2020). In the process of Covid-19 pandemic, social distance and quarantine practices have increased the need for social support and care both in terms of physical health and psychosocial aspects. Smart eco-social villages are recommended as important living spaces in terms of facilitating the living conditions of individuals through digital technologies in the rural area, observing their mental and physical well-being, especially strengthening them in psychological sense and enhancing their resilience and active participation in the society (Smart Villages, 2018; Smart Eco Social Villages, 2019). In the current study, the importance of smart eco-social villages for both individuals and society to adapt to the new normal during and after the Covid-19 pandemic is explained in relation to sustainable rural development.

WHY SUSTAINABLE RURAL DEVELOPMENT?

Rural areas are generally settlement units with low population density, based on agricultural economy, with relatively low income and social facilities (Can, 2007). Low level of socio-economic development, difficulties in accessing to basic services, inadequacy in agricultural production, and environmental and cultural heritage being under threat are amongst the common problems in rural areas. These problems also result in the increase in the migration from rural to urban areas. With increasing immigration rates, various problems arise in cities such as squatting, adaptation to urban life and mental health problems. Besides, the population concentrated in the cities causes the investments to be made predominantly in the cities and thus the development difference between the urban and the rural deepens (Kut, 2013). These impossibilities in rural areas are important determinants affecting the welfare levels of individuals. In order to improve these determinants, it is important to increase the welfare in the rural areas, to develop the society in terms of economic and social aspects and to create sustainable living conditions. In order to ensure this, it requires a comprehensive and planned process that can be achieved through community development. Providing access to basic services in rural areas, improving living conditions, ensuring social and cultural development, reducing the differences between rural and urban areas and preserving existing resources may be possible with rural development.

Rural development covers all initiatives developed to ensure sustainability in agricultural production and to create habitable areas in rural areas (Kaypak, 2012; Abukan & Yıldırım, 2019). Rural development, as stated in the "Our Common Future" report published by the World Environment and Development Commission (WCED, 1987), is a development approach that refers to "ensuring ecological, economic and social development from the perspective of economic growth and environmental protection". This approach forms the basis for sustainable rural development with the emphasis on proper use of resources (Kaypak, 2012). Within this scope, the unsustainability of production and consumption systems, rapid consumption of resources and damage given to the environment constitute the starting point of sustainable rural development. Sustainable rural development includes economic and social development compatible with the environment. Initiatives aimed at preserving the authenticity of the local in rural areas and increasing income and employment are important (Kaypak, 2012; Yalçın & Yalçın, 2013). In addition, participation, improvement of living and working conditions and protection of cultural and natural life are important for sustainable development (Kut, 2013). Sustainable rural development aims at increasing the welfare of individuals in rural areas, protecting societal and cultural heritage, strengthening local communities, reducing poverty, protecting environmental and natural resources and mobilizing coordination, orientation, participation, monitoring and evaluation mechanisms among organizations (Güleryüz, 2013). In this context, sustainable rural development embodies ecological, economic and social components within itself. Furthermore, initiatives of sustainable rural development feed the trends of returning to nature and rural areas which uses sustainable life as base.

On the other hand, with the Covid-19 pandemic, the increase of inequality between geographies, poverty rates and ecological vulnerability reveals the need for a sustainable development approach (UNDP, 2020). The sustainable development approach basically consists of 17 global goals which include no poverty, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, peace, justice and strong institutions, sustainable cities and communities, responsible consumption and production decent work and economic growth, industry, innovation, and infrastructure (UNDP, 2019). "Reduced inequalities" was determined as one of the sustainable development goals by the United Nations in May 2020. According to the inequality report titled "Dignity not Destitution" published by Oxfam (2020), it is stated that more than 420 million people may remain below the poverty line due to the Covid-19 pandemic.

On the other hand, there are discussions that governments and institutions have failed in implementing these global targets on issues such as the health of ecological systems and reducing inequalities (Saripek & Taşdemir, 2017). From this point of view, the necessity of a more equal, inclusive and sustainable approach is emphasized by focusing on the

different dimensions and effects of the Covid-19 pandemic in physical, spiritual, economic, social and global terms (United Nations, 2020).

Smart Eco-social Villages for Sustainable Rural Development in the Focus of Covid-19 Pandemic

“Covid-19” is a biological, ecological and social crisis that has affected the whole world and has emerged as a result of human-nature interaction. People interact with nature in order to sustain their lives depending on production and consumption. This interaction may sometimes lead to permanent damage in nature (Kılıç, 2006). The Covid-19 pandemic, which emerged as a result of this deterioration in the ecosystem balance, spread rapidly among individuals, and isolated lifestyle based on infection risk and quarantine practices continued for a long time. Individuals faced different problems in terms of physical, spiritual, social and financial aspects and it was difficult for them to adapt to the new normal (UNDP, 2020). In this process, especially individuals residing at rural area may encounter difficulties in accessing to health services and providing hygiene conditions, and farmers and business owners engaged in agriculture and animal husbandry may experience social and economic problems. Some researches having been recently conducted also support this situation (Cao et al., 2020; Ranscombe, 2020). In the study conducted by Cao et al. (2020), it is stated that individuals living in the city perceive “living in the city” as a protective factor in the Covid-19 pandemic process and this has an effect on anxiety. The reason for this is explained by the imbalance between urban and rural areas due to insufficient economic, cultural and educational resources (Cao et al., 2020). In another study, it is stated that it may be difficult to deliver health services to rural areas in some countries where the average age of individuals living in rural is high (Ranscombe, 2020). For this reason, it is suggested that countries must adopt a systematic approach to the pandemic, in a way to take the socio-medical, socio-economic and socio-political effects into consideration, acting in cooperation in the distribution of available resources (Ranscombe, 2020).

The devastating effects of the Covid-19 pandemic on both individual, local and international levels reveal the need for smart eco-social villages as alternative living spaces that are more sustainable, healthy and integrated with nature, in connection with the trends of returning to rural.

Smart eco-social villages at the basis of sustainable and rural development are based on the local culture and environmental centered approach, which takes digitalization as a facilitating tool in agricultural production activities and is grounded on innovative services depending upon advanced technologies in rural development. This approach is based on the understanding of developing rural infrastructure and strengthening local communities in a way to be based on participation, inclusion and democracy in society (Gülerüz, 2013; Smart Villages, 2018; Smart Eco Social Villages, 2019)

Smart eco-social villages provide activities on the basis of increasing the quality of life of individuals from different groups such as children, young people, disabled people, women and the elderly, protecting and renewing nature. Smart eco-social village practices can contribute to the development of rural policies compatible with digital technologies in order to identify and solve existing problems for individuals living in this area, improve their living conditions and thus ensure rural development (Smart Villages, 2018; Smart Eco Social Villages, 2019).

The social-economic impacts of Covid-19 pandemic depending upon demographic and geographical features in rural areas (high average of living population, long distances) in addition to the infrastructure are seen and the pandemic increasingly encourages the transition to digital environments and e-services in the field of work and education (OECD, 2020). Smart eco-social villages with its digital infrastructure and accessibility are important in terms of the development of an online service infrastructure for meeting basic needs such as education, health and housing in rural areas. Moreover, it has a significant potential for a more sustainable life in terms of energy production, consumption, acceleration of digitalization in rural areas, strengthening local communities, enhancing the resilience of rural residents and facilitating the organization of communities for this (OECD, 2020; Phillipson et al., 2020). In addition, smart eco-social villages can provide opportunities for forming an online counseling system for individuals in rural areas who need support concerning mental health along with the pandemic, fair distribution of resources, equal opportunities amongst individuals, active participation of individuals in decision-making mechanisms, and identification of cases in the pandemic process (OECD, 2020; Phillipson et al., 2020).

CONCLUSION

The Covid-19 pandemic has affected many countries around the world from economic, political, social, legal and cultural aspects in different dimensions. Rural areas may be more fragile in this process due to their existing disadvantages. For

this reason, it is important to create rural-specific solutions that will enable rural areas to come out being less affected by this process. In this context, smart eco-social villages can be a good alternative. Because in this pandemic process during which more solidarity is needed than ever, **smart eco-social villages** can provide opportunities more habitable settlements in terms of social, economic, ecological, cultural and spiritual aspects. It can also reduce the consumption of environmental resources, contribute to the recycling of resources and strengthen these areas in terms of health, education and nutrition. In addition, with its digital infrastructure and accessibility opportunities, smart eco-social villages can provide a strong infrastructure and ensure traditional values and cultural elements to survive in the era of digitalization (Roseland, 1998; Güleriyüz, 2013). With all these aspects, smart eco-social villages are related to sustainable rural development initiatives and are in an important position to strengthen rural areas during the Covid-19 pandemic. Therefore, it can be suggested that every country should invest in the infrastructure of smart eco-social villages in their rural development policies and focus on the people living in these villages and the environment they live in whilst making these investments.

In investments to be made in smart eco-social villages, the protection of biodiversity in the ecosystem and active participation of local communities should be considered. It is necessary to attach importance to meeting the basic and social needs of the individuals living in rural areas, enhancing job opportunities in rural areas and thus ensuring rural development. On the basis of participatory approach, advanced digital infrastructure and sustainability; smart eco-social villages are important for both sustainable rural development and the well-being and empowerment of individuals living in the rural, in addition to the digital infrastructure and accessibility in rural areas. Therefore, while investing in the infrastructure of smart eco-social villages, the needs and problems of the individuals living in these villages, the existing resources and potential of these villages and their socio-economic structure and technological infrastructure should be well analyzed.

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The digital transformation in public sector as a response to COVID-19 pandemic: The case of Greece

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Abstract

Nowadays, countries and industries are facing many challenges due to many technological developments. The public sector in most countries makes efforts to adapt to the new environment and take advantage of the new technologies. Thus, not only do they improve their efficiency but the experience and the satisfaction of their citizens. Some countries have managed to a large extent to adopt new technologies on their endeavor to reduce bureaucracy and improve their efficiency, but some others have still to cover a long distance to reach the desirable outcomes. Greece is a country whose public sector was lagging behind other European countries in terms of technological innovation. However, over the last years and especially the last months, after the outbreak of COVID-19 pandemic, Greece has taken considerable steps to modernize its operations and protect the citizens and employees from the pandemic. The public sector developed online systems and promoted e-governance, enabling the citizens to gain access to various public authorities without physical presence and the public servants to work and interact with their colleagues remotely. Thus, the citizens could exchange official documents with the authorities such as certificates and prescriptions, reducing bureaucracy, waiting lists, and the risk of spreading the virus. Many Ministries developed new systems as a response to the lockdown due to the pandemic. The Ministry of Citizen Protection and the Ministry of Digital Governance developed a five-digit number in order for the citizens to inform the authorities about their movements, as well as cell broadcast messages sent on all smartphones in Greece with general instructions about the pandemic. Also, the Ministry of Tourism created a digital portal whereby Greece is advertised worldwide throughout the pandemic through videos, virtual guided tours, and testimonials. The data imply that the digital transformation of the public sector is welcome by the citizens.

KEYWORDS

Digital Transformation, E-Government, ICT, Public Sector

INTRODUCTION

Digital transformation has emerged as a term over the last decade, aiming at redesigning public and private sector services from scratch to improve daily work of employees and public servants, meeting at the same time citizens' needs effectively. However, the outbreak of the COVID-19 pandemic caused several problems, not only in terms of public health, but also in public sector's operations globally.

Greece, lagging behind many other advanced countries, had to take huge steps towards the digitalization of many of its operations to both shield citizens from the pandemic and deliver services more effectively and timely. This health crisis heightened the need for all countries, let alone Greece, to focus and invest more to new technologies, ICT infrastructure, as well as policies oriented to the modernization of public sector.

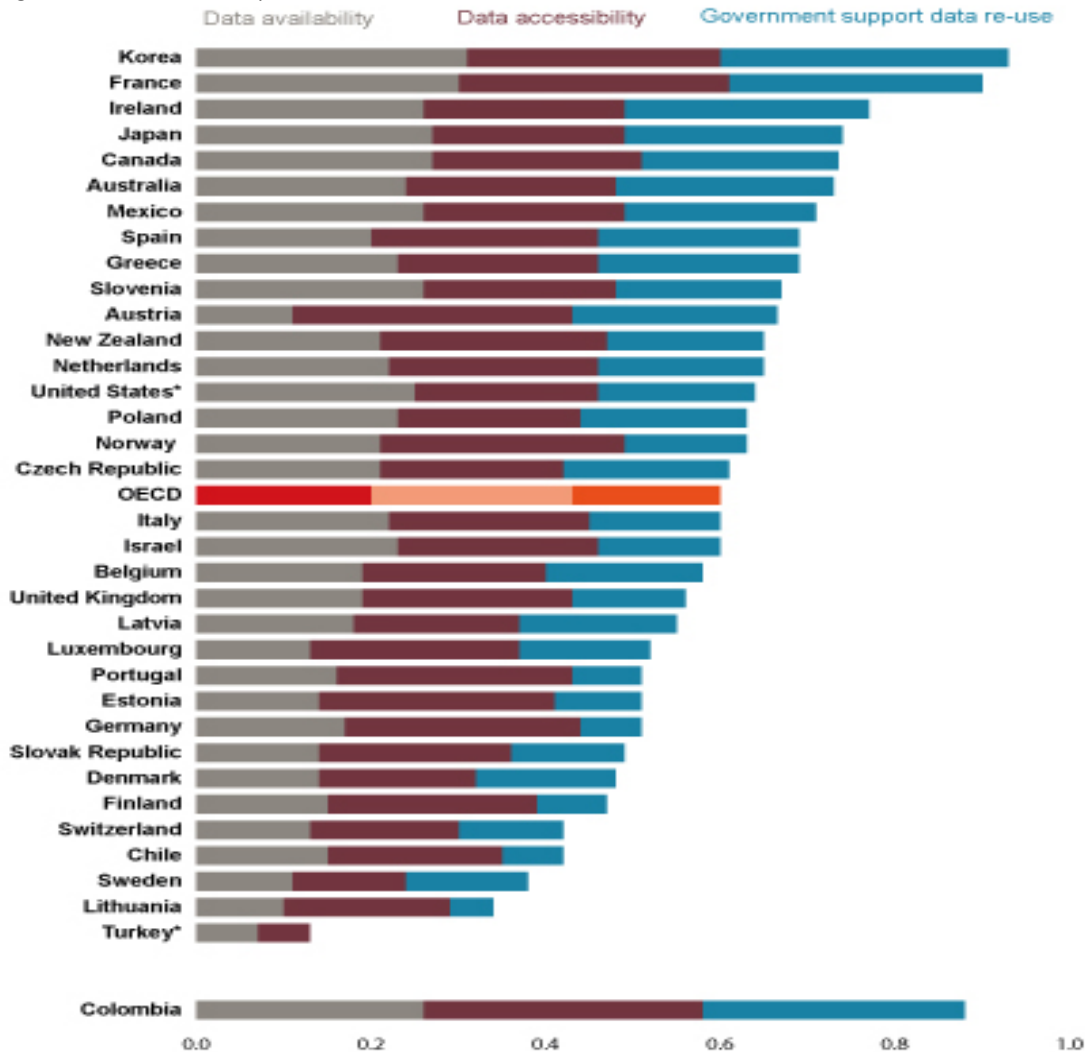
Therefore, this paper aims to record the huge digital transformative steps of public sector in Greece over the pandemic period and the acceptance that this digitalization has by citizens as well.

BRIEF LITERATURE REVIEW

While many papers discuss the dynamic capabilities in the private sector (Teece, 2016 and Helfat and Martin, 2015), only a few papers examine the dynamics and the innovation in the public sector. Breznitz (2007) and Block (2008) show that there are many public organizations and bodies, even whole countries that manage to create change and amend the way that they work and deliver their services to the public.

Janssen et al. (2012) mention that e-government is an increasing area of interest for public sector practitioners through Open Government Data (OGD), since it allows the government agencies to release to the public the data that they collected in an accessible, understandable and redistributable way. The last OECD at a glance report shows that Greece fares very well (9th place), ranking above the OECD average and countries like Germany, Italy, United Kingdom, and Norway among others (Figure 1). Heeks (2001) stresses three major contributions of e-governance, namely government process, connecting citizens, and building external interactions by studying case studies from Chile, South Korea, Honduras, and the Philippines.

Figure 1 OURdata Index: Open-Useful-Reusable Government Data 2019



Source: OECD Government at a glance, 2019

Note: *Data for United States and Turkey is from 2017

**Composite index: 0 lowest to 1 highest

THE DIGITAL TRANSFORMATION OF THE PUBLIC SECTOR IN GREECE AMID COVID-19 PANDEMIC

The Measures Taken For The Digitalization Of The Public Sector

Greece, like most of the countries worldwide, introduced restrictions on public movement put into effect on March 23, 2020. To surveil effectively the movements of citizens during the period of lockdown, the Ministry of Digital Management launched the 11033 hotline, where residents had to send a text message for permission for some specific categories of outings, such as visiting a doctor, a pharmacy, a person in need, a supermarket or going out for physical

activity. This service is free of charge and does not store data, nor does it keep records and was only active over the period that the restriction measures due to COVID-19 pandemic were in effect.

In line with 11033 hotline, 112 is an integrated emergency communications service, launched by the General Secretariat for Civil Protection. This service includes both inbound and outbound components, allowing citizens not only to call in case of emergency from Greece or everywhere in the European Union, but also to receive text messages, emails or voice messages on their cellphone, landline telephone, tablet, laptop or desktop computer.

One of the most important measures, which is considered a real breakthrough in the digitalization of the public sector in Greece is the platform gov.gr, launched on March 20, 2020. This platform is the new unified digital portal of public management, where citizens and businesses can have access to digital services of their interest easily and quickly. Table 1 shows the various categories and some indicative services that this platform covers. In total, the platform gov.gr includes more than 549 digital services from 18 departments, 53 agencies and organizations, and six independent authorities.

Table 1 Categories that the platform gov.gr covers

Category	Indicative services
Agriculture and Animal Husbandry	Agricultural entrepreneurship, allowances, insurance of agricultural production, etc.
Education	Digital skills, Student life, School registration, etc.
Labor and Insurance	Information about insurance, retirement, compensation, job training, etc.
Justice	Legislation, issuance of criminal record, etc.
Family	Online issuance of birth and marriage certificates.
Health and Welfare	Prescriptions, Personal Health Record, Appointments with doctors, etc.
Culture, Sports and Tourism	Catalogue of public libraries, digital library, museums, etc.
Property and Taxation	Information about personal vehicles, taxes, tangible and intangible property, etc.
Enlistment	Information about military academies, Personal military number, enlistment, etc.
Citizen and Daily life	Information about the environment and quality of life, legislation, telecommunications, payments and administrative fees, consent forms, etc.
Business	Business property, Business record, Corporate taxation, Recruitment, etc.

Also, the COVID-19 pandemic forced the public sector to develop new technologies to enable public servants to work remotely, without letting pandemic to affect the provision of quality public services to the citizens. Thus, the Ministry of Digital launched the platform e:Presence.gov.gr on March 13, 2020, whereby all public bodies and public servants can hold video conferences. The most crucial trait of this service is that it offers quality, quick, and most importantly secured interaction between the public servants since in many cases there are confidential and classified issues covered from the different bodies of the public sector. Likewise, the e:Presence service offers the same privileges to members of the Greek academic and research community, enabling them to organize and participate in high definition and secured video conferences.

Education is another crucial sector that is affected heavily by the COVID-19 since students could not attend any courses after the outbreak of the pandemic. Therefore, the Ministry of Education and Religious Affairs acted at once by using both synchronous and asynchronous e-learning methods through a wide range of tools. More specifically, platforms e-me and e-class enabled students of secondary education to attend their classes online via either cell phones, free of charge, or tablets and computers. These platforms assisted students in keeping them up to date with their professors and course material, staying at the same time healthy, both physically and mentally.

Digital platforms are also used for promoting Greek tourism globally. Specifically, Discovergreece.com is an online consumer platform of Marketing Greece, a non-profit initiative of the Greek Confederation and the Hellenic Chamber of Hotels in cooperation with state, aiming at promoting and enhancing Greek tourism in difficult times when tourism exhibitions cannot be held as a result of the social distancing restrictions worldwide due to COVID-19 pandemic. Therefore, this online platform offers high-quality experiential content, such as videos, photographs, and testimonials, and runs campaigns in seven different languages.

The Success Of New Technologies And Their Acceptance By Citizens

The available data regarding the users of the provided services imply that digital transformation of the public sector is in the right direction. Table 2 displays the number of users in absolute numbers between some of the major services provided by the public sector.

Table 2 Number of users per online service

Service	Number of Users	
	Number of students	Number of teachers
e-class (Secondary education)	755,625*	117,126*
e-me (Secondary education)	369,416**	72,873**
	Number of video conferences	Number of public servants
e:Presence.gov.gr	17,289**	24,470**
	Number of video conferences	Number of professors and researchers
e:Presence	73,583***	43,345***
11033 hotline	110 million sms sent****	
Intangible prescriptions	375,000 insured have registered****	

Note: *According to the last available data (May 10, 2020).

**According to the latest data (August 24, 2020).

***According to the latest data (August 24, 2020). These data do not account only for the period after the Coronavirus pandemic, but also for the whole period that this service is in operation (2011 onwards).

****According to the latest data (May 26, 2020).

CONCLUSIONS

In conclusion, despite the negative effects of COVID-19, the Greek government seized the opportunity to develop and upgrade the e-government services in order to help the Greek citizens to be connected with government services while staying at home during the lockdown.

This development was not only crucial for making governmental services safer, easier, and user friendly for the public in the battle against COVID-19, but also for making much needed services available online reducing the time for implantation. Lastly, Greece continues the expansion of its digital services in many more sectors to achieve a unified governmental system and help companies and citizens to benefit from this implementation saving money and resources.

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The Effects of COVID-19 in the European Airline Industry. Results from Pest Analysis.

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Abstract

The impact of COVID-19 outbreak was huge and rapid for the European airline industry. International and domestic traffic in European airports reduced dramatically, with severe effects to the public and private sector. This paper proposes a Research Framework for the European Airline Industry, in a coronavirus-safe environment. Choosing qualitative research approach, this paper utilizes data collection as a research method for performing a PEST analysis, in order to better understand the effects of COVID-19 in the European Airline Industry. The results of the assessments of current political, economic, social and technological factors, in relation to COVID-19 threat, leads to the conclusion that the European airline industry is in an unprecedented situation and needs radical changes. Further investigation of the impact of COVID-19 in the airline industry in every European country is recommended with additional factors to be examined.

KEYWORDS

Covid-19, Airline Industry, Europe, Pest Analysis.

INTRODUCTION

Coronavirus disease (COVID-19) is an infectious disease, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). It was first identified in December 2019 in Wuhan, China, and has resulted in an ongoing pandemic. As COVID-19 transmissions spread worldwide, governments began recommendations to avoid travel and then announced and enforced both domestic and international travel restrictions. These restrictions affected the trend of flight networks around the world. The date of travel restriction enforcement varies by country; therefore, the period and degree of flight reductions and airport closures also varies by country and continents. These flight reductions and airport closures had an unprecedented impact on the aviation sector.

In order to summarize and categorize COVID-19 effects in the European Airline Industry, the researchers chose to use PEST analysis. The collection and analysis of data gathered from various sources leads to conclusions regarding the current state of the European Airline Industry, its related problems, and prospects for the future. This paper first presents the research design and methodology, it continues by analyzing the four prediscussed factors and it concludes by mentioning the findings of the research and thoughts for the future.

RESEARCH DESIGN AND METHODOLOGY

This paper is emphasizing on the effects of COVID-19 in the European Airline Industry. The research strategy in which is based, is PEST analysis. PEST analysis is a powerful tool for understanding strategic risk. It identifies the changes and the effects of the external macro environment. (Porter,1985). PEST analysis examines four categories of external environmental factors, which are: Political factors (P): these cover various forms of government interventions and political lobbying activities in an economy. Economic factors (E): these mainly cover the macroeconomic conditions of the external environment but can include seasonal considerations. Social factors (S): these cover social, cultural and demographic factors of the external environment. Technological factors (T): these include technology related activities and technological changes that affect the external environment (Sammut-Bonnici and Galea, 2015).

The researchers mainly utilized Google Search Engine for gathering, reviewing and synthesizing large amounts of secondary data that were obtained from reliable sources like newspapers, periodicals, websites, and various publications. Then, they isolated those that have scientific research related to the topic and combined the new knowledge to the already existing one that comes from academic research to extract useful findings.

The aim of the findings is to help organizations and companies that operate in the European Airline sector, to successfully react to the COVID-19 threat, to identify future trends, to mark opportunities and to make contingency strategy for future threats.

Political Factors

The pandemic of COVID-19 outbreak had an enormous effect on the International and European airline industry. The majority of the governments had to take hard restrictions in order to avoid the spread of the virus. Each government had travel restrictions to foreign countries that they change each day, according to the reports of COVID-19 cases that they have. Governments recognizing the negative impacts decided to give bailout packages. Such examples are France that strengthened Air-France with 7 billion euros and Germany that offered 9 billion euros to Lufthansa. Also Italy took a decision to give all the 500 million COVID-19 funds to the airlines despite the different EU directive (Davies and Tidey, 2020).

On the other hand, European Commission tried to create a united front with its Member States. It presented a transport emergency package in 29 April 2020, where the European Council adopted a temporary amendment to the rules on air services to support airlines and airports. Also, in 21 July 2020, European leaders reach a deal on the recovery plan for Europe. Eurocontrol, also helped by offering an update on the latest measures taken by European States and major European airlines, in response to the COVID-19 pandemic (COVID-19: Council Adopts Relief Measures for Aviation and Railways, 2020).

Other associations, such as ACI EUROPE and EASA signed a Cooperation Agreement as airport industry publishes Guidelines for a Healthy Passenger Experience and there is also the joint EASA/ECDC COVID-19 Aviation Health Safety Protocol (Airports Council International Europe, 2020).

So, in order to surpass this extraordinary situation, Governments, in association with the EC, WHO, ECDC, IATA, ICAO, EASA, ACI Europe, Eurocontrol and other related associations, started to cooperate, always having as a priority a healthy, sanitized environment for airline passengers and employees. Governments and EC must also take into consideration legal aspects of personal data and data security.

Economic Factors

The airline industry faces an economic catastrophe as travel restrictions and airport closures caused a significant decline in passenger numbers and revenues in rapid time. ACI EUROPE reported that passenger traffic across the European airport network stood at -98% in May 2020 and at -93% in June 2020, compared to the same period last year (Airports Council International Europe, 2020). The economic results are beyond compare. There was an approximately 44 billion USD revenue loss in Europe from Jan to June 2020. The estimated impact on international passenger traffic and revenues for 2020 was in: i) capacity -51% to -61% ii) in passengers -528 to -634 million and iii) in revenue -73 to -87 billion USD. The estimated impact on domestic passenger traffic and revenues for 2020 was in: i) capacity -32% to -37%, ii) in passenger -127 to -159 million and iii) in revenue -10 to -13 billion USD.

In contrast to the enormous fall in passenger traffic, cargo flights showed a slight fall with the increased cargo-only operations using both cargo and passenger aircrafts in order to transport not only crucial medical supplies but also all types of products (Cargo Checks in as the New Passenger, 2020).

Airline companies can categorize economic results due to: a) reduction of customer demand, which leads to changes in bookings, ticket refunds and cancellations, b) finance, with changes due to covenant ratios, existing and new facilities, contracts etc, and c) operations, with working capitals, maintenance obligations, available seats, costs from new health rules like cleaning and disinfecting of the cabin etc.

Some of the responses that airline industry considered include temporarily requesting voluntary furloughs, laying off significant numbers of staff, deferring aircraft/engine maintenance, cancelling purchase orders to reduce operating costs as quickly as possible to preserve liquidity. Airline bankruptcies, mergers and acquisitions are also likely to occur. Some economic relief came from governments, from airports and from other associates. (Ramsey, 2020)

For the near future, airline companies can ally with airport companies and other associated parties for economic advantages. Cargo flights also open a window of opportunity for airliners such as Airpartner. Airline companies can also alter their focus on destinations. Such an example is Lufthansa that has incorporated a new entity named Ocean to operate long-haul flights to tourist destinations (Cirium, 2020).

Social Factors

Due to COVID-19, W.H.O announced travel restrictions that were necessary in order to avoid the spread of that disease. As a result, passengers stop travelling and this had a negative impact on the interpersonal social relationships. Families and friends, colleagues etc. stayed apart, facing disappointment and social distancing. Also many companies due to low demand started to lay off staff.

In Europe, Swissport announced that they will cut 4500 jobs in UK and Ireland. British Airways announced that they had to cut up to 12.000 jobs due to COVID-19. Easyjet had to slash 30% of its workforce that amounts in 4.500 jobs. Ryanair had to cut 15% of its workforce about 3000 jobs. Air France announced a schedule till 2020 that 7500 jobs will be cut from the mother company and the regional subsidiary. (Coronavirus Job Cuts: Which Companies in Europe Are Slashing Their Workforces Because of COVID-19?, 2020).

As professor David Blustein (counselling psychology) of the Boston college says "This is going to be a global pandemic of unemployment"(Fowler, 2020). Many of the employees suddenly found themselves without work or with less money in their pocket. All the above, led to significant social problems. Former employees were found, no longer able to meet their obligations or, even worse, could not provide the basic needs for their families. Psychologists note that losing a job is equally of a loss of a loved one. That emotion includes all the stages of grief, which run from shock and denial, through anger and bargaining till the worst such as commit a suicide. Also, airplane operators, airport operators and service providers must ensure that physical distancing of 1,5 meters is maintained wherever this is operationally feasible, which also leads to social distancing and other numerous consequences.

Technological Factors

Companies related to Airline Industry have found potential assistance on technology in order to keep travelers safe. Robots can serve customers instead of employees for the sake of everyone's safety in many cases since the Coronavirus became a pandemic case (Chung-En, 2020). Innovation also serves the sector of masks industry and helps people cover their mouth and nose for safety issues. 3D printed masks are a cost effective method to produce massive amount of masks in less time (Imbrie-Moore et al.,2020). Technology can also help the fight against COVID-19 with vaccines and relevant tests which must be cheap, quick and with minimum consequences.

On the battle against COVID-19 citizens among the world and Governments have the opportunity to tackle the issue of COVID-19 Spread with the smartphone technology that rises worldwide. Sensors that have become essential for every smartphone the last years have been utilized in order to provide COVID-19 related services that assist users to prevent them from being infected (Coronavirus Contact-Tracing Apps: Can They Slow the Spread of COVID-19, 2020).

In the category of Location Based Mobile applications, Health Status LBMA are those that provide useful information regarding the behavior of COVID-19 and help users identify the related symptoms in case they are infected (Rózanowski et. al., 2013). "HSE COVID-19HSE COVID-19" in Ireland is such an application.

A second category is the Safe Distancing LBMA where the location of end-users is monitored by the smart device of the user and routes of the infected users are being published in order to avoid the further spread of the virus (Lim, 2020).

A related example is the mobile app "Smittestop" created in Denmark. Another major category is COVID-19 Mapping that provides insights regarding the spread in a nearby area (Boulos et.al., 2020). "COVID Community Alert" in Italy is such an example.

COVID-19 Geosocial Media is another example where users can share information regarding the COVID-19, and also some users can ask help in case they need assistance in case they are not allowed to go out. Finally, Wechat is a mobile application where businesses and entrepreneurs can participate in order to produce COVID-19 technology related solution to the end-users (WeChat and Global Peers Launch COVID-19 Global Hackathon to Support the World Health Organisation, 2020).

CONCLUSIONS

Pandemic Crises have a certain frequency and lifecycle among the years, and global community may be not so unprepared as it was stated on the beginning of COVID-19 spread for the sake of everyone safety numerous sacrifices have been made globally in order to prevent this crisis to become a disaster.

This paper used PEST Analysis as a valuable tool, in order to understand the effects of COVID-19 in the European Airline Industry and to offer value to all related parties, such as airline companies, governments and other organizations. By obtaining large amounts of relevant data and molding them with PEST method, this paper reached to specific findings. The results suggest that European Airline industry has to keep working to make its ecosystem as safe as possible, taking

into account the four major categories of aspects we highlighted into our research. All associated parties, (airlines companies, governments, EC, and other organizations must make tough political decisions for the sake of the European airline sector. Airline companies have to ensure financial viability and consider new ways of being profitable again. By cutting off all the unnecessary costs and by stimulating increase of flights they can accomplish that, always having health as a priority. Various social factors as unemployment and social distancing are to be seriously considered. Finally, digital technologies for safe flights will boost this industry and will have the potential to assist governments and companies, always with respect to human rights.

Table 1. PEST Analysis Results

Factors	Results
Political	EC and Governments must have as a priority the safety of their citizens. EC and Governments are suggested to offer economic support to companies that are registered or operate within their territory. EC, Governments and related organizations can focus on contingency and future plans. Governments have to always operate in accordance to EC rules and legal restrictions.
Economic	Companies are suggested to cut any unnecessary costs and possibly change their structure in order to surpass them loses. Companies are suggested to cooperate with governments, EC, relative organizations and other companies for healthy, sanitized travel and travel-related services. Companies can change their target areas or switch to cargo flights for more profit.
Social	Travel restriction minimized interpersonal social relationships. Social distancing and job cuts have tremendous effects to people. Governments and other social organizations are suggested to help people and families.
Technological	Robots and other technological innovations can help in the fight against COVID-19. Technology can also help the fight against COVID-19 with vaccines and relevant tests. Smartphone technology with sensors, LBM applications, COVID-19 mapping and Geosocial Media , can also be used for valuable solutions. Technology is suggested to be in accordance with the governments and with the European community.

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Economic impact analysis to air transport due to pandemic Covid-19

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Abstract

Air transport and economic development interact with each other as aviation makes significant direct and indirect contributions to the economy and increases the cycle of economic activity. Due to Covid-19 pandemic, air transport sector could experience a huge reduction of direct and indirect contribution in economy. Given that demand for air travel is falling dramatically during the Covid-19 pandemic, not only among tourists but also among business travellers, as many travel restrictions come into force, it is crucial to provide an assessment of the impact of Covid-19 on the air transport sector in Europe and its domino effect in air transport sector in Greece. Key challenge in this period of economic downturn with travelling restrictions, is to increase Greece share of the Mediterranean tourism market and support Greece's ability to achieve high income from air transport activities including direct, indirect and induced impacts, which are related to the total revenues of the air transport industry as well as the enabler of the spin-off effects on tourism – which plays a key role in promoting economic growth in Greece. The purpose of this paper is to provide quantitative estimations on the economic effects of air transport due to Covid-19 pandemic. This paper focuses on the estimation of the air transport footprint in terms of socioeconomic impacts in national economy. The socioeconomic effects assessment concept and methodology are given, providing an essential tool for stakeholders and decision makers. The numerical application is Greece, which is an extremely attractive summer holiday tourist destination in southeast Mediterranean, being very highly affected by the air transport and travel restrictions due to COVID-19 pandemic.

KEYWORDS

Management Science in Travel and Tourism, Risk Analysis and Management, Mathematical Modeling and Decision Making, Air Transport, Economic impact analysis, Covid-19 pandemic

INTRODUCTION

In order to tackle pandemic COVID-19, countries globally responded with strict measures such as lockdowns and social distancing regulations to minimize the spread of the virus, resulting in an immense reduction in transport activity. During the lockdown, there was a reduction of 60-80% for all transport modes across all regions and especially for air traffic, which approximately decreased -90 % compared to a year ago (European Commission, 2020). Therefore, air transport sector is one of the sectors that most has floundered and badly exposed to the impacts of the shock by reduced mobility. This paper is focused on the determination of impacts of Covid-19 pandemic on the European and Greek air transport network, in terms of traffic.

The recent months marked by the outbreak of the crisis due to COVID-19 have not only severely affected people who became infected and their families but have also dealt a heavy financial blow to businesses, with particular emphasis on transport companies. Particularly in terms of air transport, the exacerbation of COVID-19 has a significant impact on connectivity worldwide and especially in the European Union. The measures to curb the outbreak have resulted in a drastic reduction in air transport activity, especially in passenger transport. Freight flows were less affected, in part because of the EU's collective efforts to ensure that goods continue to be transported, despite a decrease due to the declining economic activity and the cessation of supply chains.

Major changes have been made to unnecessary travel (Com.2020, 1) and specific transport measures have been taken, including guidelines on border management measures (Com.2020, 2,3), the implementation of "Green Lanes" for the passage of border for the transport of goods (Com.2020, 4) as well as measures to facilitate freight air transport (Com. 2020, 5.6).

As long as there are still restrictions on movement and it is still possible to affect commodity flows, the above measures and recommendations on the flow of goods, the free movement of workers in critical occupations, the passage and repatriation of passengers and crews will continue to be implemented in a coordinated manner by all Member States of the European Union and will continue to use the National Transport Contact Points Network in order to deal with COVID-19 pandemic as coordinated by the European Commission (Com.2020, 7).

In March 2020, all bi-directional traffic flows between Europe and other regions in the world decreased with various dynamics and amplitude. The flow with Asia/Pacific is now the largest share of traffic to/from Europe at 10% and has constantly slightly increased since 1 April. In the first 10 days of May, the flow intra Europe (within) reduced by 90% compared to the same period in May 2019 but its share reduced only slightly from 80% to 70% and remained by far the largest flow. The flow to/from Asia/Pacific reduced by 54% but is now the largest flow with 10% of the total flows compared to 3% in 2019. The flow to/from Middle East (respectively North Atlantic) which was the 2nd flow in 2019

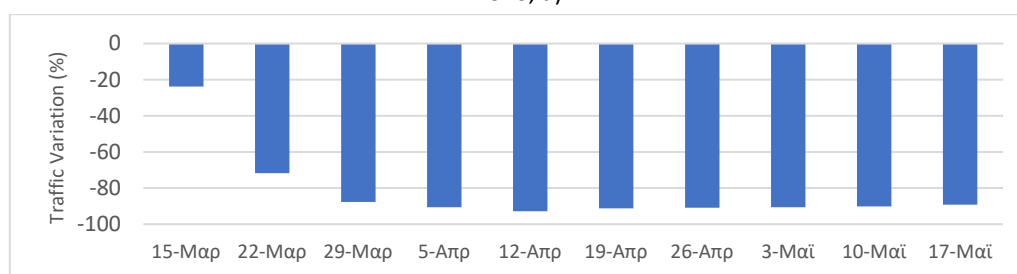
(respectively the 3rd) has reduced by 80% and represents now 7% of all the flows. This time last year, all-cargo flights accounted for about 2% of total Departure / Arrival flights, whereas now, it accounted for 14% on 9 May 2020. The share of scheduled traffic, which accounted for 86% reduced to 33% only. It appears clear that over the crisis period all-cargo flights remained stable at the 2019 level with a variation around the Easter period (both 2019 and 2020) while scheduled and low-cost traffic reduced by 92% (respectively 98%) during the crisis (Eurocontrol 2020, a).

Comparing the effects of SARS-COVID - II (or COVID-19 disease) to date with the effects of SARS-2003, the impact of SARS - COVID - II has already outperformed the impact of SARS in 2003, which reduced RPKs in the year 2003 by 8% and had caused a reduction of 6 USD billion in revenue for Asian / Pacific airlines. According to the latest IATA data, the plan to fully restore the SARs epidemic in 2003, which lasted 6 months, does not seem to be easy in the case of the COVID-19 pandemic.

EFFECTS OF COVID-19 ON THE EUROPEAN AIR TRANSPORT NETWORK

The outbreak of COVID-19 has overwhelmingly affected air travel across the EU, but the effects vary between Member States, areas, and regions. Overall, in the European Sky, the daily variation of traffic compared to the corresponding day in 2019, took prices from -23.8% on March 15, 2020, and reached -87.7% on March 29, from -90.6 on April 5 to April 5. -92.8% on April 12 and from -90.6% on May 3 to -89.2% on May 17.

Figure 1. Daily variation of total traffic in Europe compared to the corresponding day in 2019 (Source: Eurocontrol 2020, a).



Regarding the different effects between Member States, areas and regions, the daily variation in the main markets of Europe from March 15 to May 17. Regarding March 2020, the largest daily variation of the total traffic compared to the corresponding day in 2019 in the largest markets of Europe was presented on March 29, in France with a daily variation of total movement equal to -92.6%, as in Germany it was equal to 87.2% , while in the United Kingdom was equal to -86.8% and in Netherlands -85.2%.

In April, the largest daily variation of total traffic compared to the corresponding day in 2019 in the largest markets in Europe was presented on April 12 (Catholic Easter, 2020), in France with daily variation of total traffic equal to -96.2%, while in the United Kingdom was equal to -94.0%, in Germany 92.6% and in Netherlands -91.0%. In May, the daily variation of total traffic compared to the corresponding day in 2019 in the largest markets of Europe was presented on May 17, in France with daily variation of total traffic equal to -93.7%, while in the United Kingdom was equal to - 91.7%, in Germany - 86.2% and in Netherlands - 85.4%.

In March, the largest daily variation of total traffic compared to the corresponding day in 2019, in the largest markets of the Mediterranean was presented on March 29, in Italy with a daily variation of total traffic equal to -93.3%, while in Spain was equal to 92.6 % , in Portugal equal to -92.0%, in Cyprus equal to -91.4%, and in Greece to -88.8%. In April, the largest daily variation of the total traffic compared to the corresponding day in 2019, in the largest markets of the Mediterranean was presented on April 12 (Catholic Easter, 2020), in Portugal with a daily variation of total traffic equal to -98.1%, while in Italy was equal to -97.3%, in Spain equal to -96.1%, in Cyprus equal to -93.8% and in Greece to -92.4%. Finally, in May, the daily variation of total traffic compared to the corresponding day in 2019, in the largest markets of the Mediterranean was presented on May 3, in Cyprus with a daily variation of total traffic equal to -96.2%, while in Portugal was equal to - 96.1%, in Spain equal to -95.8%, in Italy equal to -94.8% and in Greece to -93.7%.

Regarding the variation of traffic for the largest Air Operator Groups, the reductions on Sunday 19 April were: easyJet -99.7%, Ryanair Group -98.5%, Air-France-KLM -95.3%, IAG Airlines and Lufthansa Group -94.1%. On Sunday 19 April Air Nostrum, Pegasus, TUI Jet and Brussels Airlines had no operations at all, whilst easyJet, Austrian Airlines, TAP/Air Portugal and Ryanair were -99% with just a few flights. Iberia was -96%, Air France -96%, British Airways -92%, Lufthansa -92% and KLM -92%. Widerøe was the busiest Airline with 111 movements, followed by Lufthansa (91), Qatar Airways (84), SAS (79), Turkish airlines (69), DHL Express (69), British Airways (67) and KLM (56).

Respectively for a typical day of May, the reductions on Tuesday 12 May were: easyJet -98.9%, Ryanair Group -98.1%, IAG Airlines -96,0%, Lufthansa Group -93.5% and Air-France-KLM -93.1%. On the same day, Pegasus, Brussels Airlines and Air Nostrum had no operations at all, whilst Austrian, TAP, TUI jet and Vueling were -99%, Ryanair was -98%, Iberia -96%, Air France -95%, British Airways, Lufthansa and Turkish airlines -94% and KLM -88%. DHL Express was

the busiest Airline with 248 movements, followed by Widerøe (187), Bristow SAS (100), Lufthansa (95) KLM and Qatar Airways (91), TNT International (88), Bristow Norway (84) and FEDEX (78).

Regarding the variation of traffic per airport, on Sunday 19 April, virtually all of Europe’s largest airports are now managing 90% fewer flights compared to last year, examples: Paris Orly -100%, London Gatwick -99%, Vienna -96%, Munich -95%, Madrid -95%, Paris CDG -93%, Athens -93%, Dublin -92%, Istanbul -92%, Amsterdam -90%, London Heathrow -86%, Milan Malpensa -85%, and Frankfurt -83%. On Sunday 19 April, Frankfurt was the busiest airport with 216 movements, followed by London/Heathrow with 190, Amsterdam (147), Oslo Gardermoen (118), Leipzig (106) and Istanbul (104).

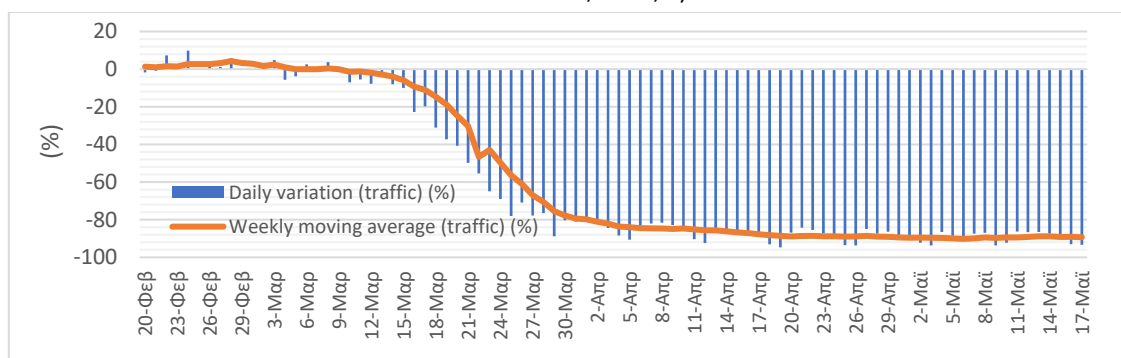
On Tuesday 12 May, virtually all of Europe’s largest airports are managing 80% fewer flights compared to last year, examples: Paris Orly and London Gatwick were -99%, Munich -95%, Vienna -93%, Dublin -90%, Madrid -90%, Istanbul -89%, Amsterdam -87%, London Heathrow -86%, Paris CDG -85%, Milan Malpensa -84%, Athens -84%, Frankfurt -84% and Oslo -77%. On the same day, Frankfurt was the busiest airport with 238 movements, followed by Paris CDG (205), Amsterdam and Oslo Gardermoen (193), London/Heathrow (192), Leipzig (185), Koln/Bonn (158) and Istanbul (121).

EFFECTS OF COVID-19 ON AIR TRANSPORT IN GREECE

Air transport is a key lever of economic activity in Greece, which has the 8th largest airline market in Europe (based on the IATA Connectivity Index²). Between 2013 and 2018, airline connections increased by 106%. The year 2020 may be the first year not only to stop the great growth of the aviation industry in Greece for the last 5 years, but also to prove a year of great losses for the aviation industry and therefore for its contribution to the country's economy. The variation of air traffic in the whole country but also in the largest airports in Greece, during the Covid-19 pandemic, is shown in the figures below.

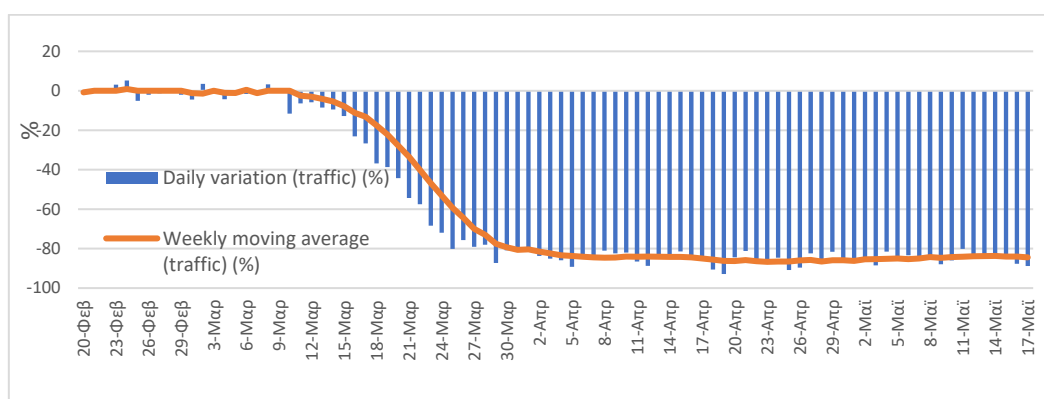
Figure 2 shows the variation in total traffic in Greece from February 20 to May 17, 2020 compared to the corresponding day in 2019 as well as the weekly moving average. In February 2020, there is a small positive variation of traffic compared to 2019, with the largest positive variation on February 24, 2020 (+ 9.8%). On the contrary, from the middle to the end of March 2020, there is a constant greater negative variation of traffic, which reaches -87.3% on March 29. In April and May, the daily total variation ranges between -80.0% and -95.0% with the highest prices occurring on April 19 (-94.7%) and May 9 (-93.7%) respectively.

Figure 2. Variation of total traffic in Greece in 2020 compared to the corresponding day in 2019 (Source: Eurocontrol, 2020, a)



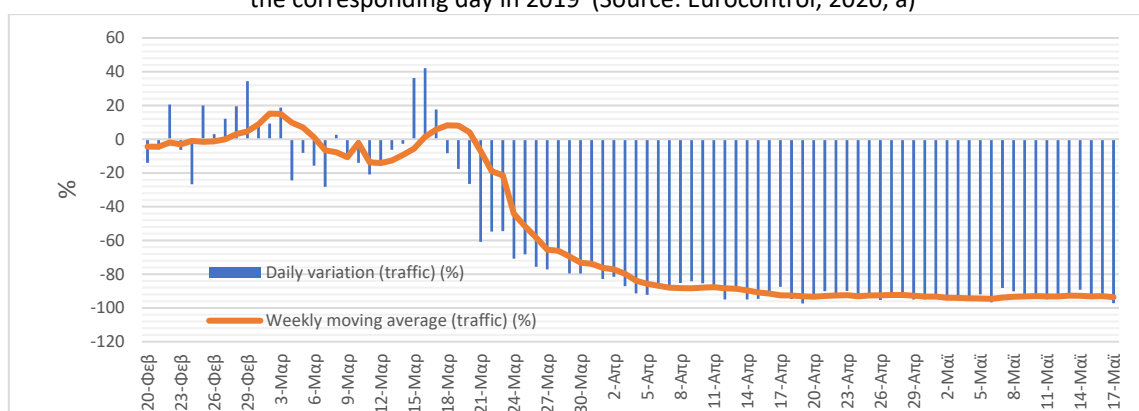
Athens International Airport (AIA), the main airport in Greece from February 20 to May 17, 2020 compared to the corresponding day in 2019. In February 2020, there is a small positive variation in traffic compared to 2019, with the largest variation on February 24, 2020 (+ 5.2%). On the contrary, from the middle to the end of March 2020, there is a constant greater negative traffic variation, which reaches -81.0% on March 31. In April and May, the range of the daily total traffic ranges between -79.0% and -93.0% with the highest prices occurring on April 19 (-92.9%) and May 17 (-88.8%) respectively. Thus, the largest airport in the country has a similar picture to that of the country (Figure 3).

Figure 3. Variation of total traffic at Athens International Airport from February 20 to May 17, 2020 compared to the corresponding day in 2019 (Source: Eurocontrol, 2020, a)



Finally, figure 4 shows the variation of total traffic at Heraklion International Airport (HER) from February 20 to May 17, 2020 compared to the corresponding day in 2019. In February and until mid-March 2020 there are significant fluctuations in traffic variation compared to 2019, ranging from -26.7% on February 24 to -36.3% on March 15. Then, from the middle to the end of March 2020, there is a steady traffic variation, which reaches -79.6% on March 30. In April and May the variation of the daily total traffic ranges between -81.0% and -97.0% with the highest prices being recorded on April 29 (-95.0%) and May 17 (-97.2%) respectively. Therefore, Heraklion International Airport has more intense traffic variation compared to the whole country.

Figure 4. Variation of total traffic at Heraklion International Airport from February 20 to May 17, 2020 compared to the corresponding day in 2019 (Source: Eurocontrol, 2020, a)



CONCLUSIONS AND PROSPECTS

COVID-19 pandemic has spread around the world without recognizing borders. It has affected all industries, all sectors and all aspects of our lives with devastating economic and financial consequences, causing great uncertainty and risk. Regarding air transport, 2020 is in danger of being the first year not only of a slowdown in the growth of the airline industry over the last 15 years, but also of heavy losses for the aviation industry as a whole.

The aviation industry has long experience in the field of safety and security management and is accustomed to operating in a highly controlled environment. Restoring passengers' confidence, that air travel is a safe way to travel will be crucial to overcoming this crisis. Hence, it is important that air carriers and health care providers take and widely notify the applicable measures, ensuring that these measures are largely visible and coordinated, and communicated to passengers anytime.

Everyone's health, including transport workers and passengers, is still a top priority. Particular attention should be paid to vulnerable populations, such as the elderly and people with underlying medical conditions, while at the same time their privacy will be protected. According to the European Commission, this relaxation should be accompanied by ongoing information campaigns to ensure that travelers can plan and act with full awareness of the situation and that they have an individual responsibility to adhere to health recommendations when traveling. The gradual restoration of transport and connectivity services will depend entirely on the approach adopted in relation to travel restrictions, epidemiological assessments, as well as the advice of scientists regarding the necessary precautions for the protection of the individual and the public health. Therefore, the EU guidelines for the restoration of transport services and connectivity will be implemented in the context of a common European roadmap.

A major challenge is the sustainable recovery of the aviation sector in this common European route map and consequently in Greece. Hence, the possibility of focusing on the restoration of transport services and its connectivity, so that there is a prospect for the aviation sector to recover before its crisis, remain competitive globally and to continue to be a cornerstone of economic growth should be a key pillar of strategic planning at European level.

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