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GMR-Hungary: A Complex Macro-regional Model for the Analysis of Development Policy Impacts on the Hungarian Economy

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1. Introduction

The National Development Office of the Hungarian government contracted the international consortium coordinated by the Center for Research in Economic Policy for the development of a complex macro-regional economic model. This model system will be used for ex-ante evaluations of different policy scenarios according to the following specifications:

1. The model is the extension of EcoRET – a macroeconomic model used for ex-ante impact analyses during the design of the 1st National Development Plan for Hungary – into the regional and the sectoral directions. For the regional extension EcoRET will be integrated with RAEM-Light – a spatial computable general equilibrium (SCGE) model that have already been used for policy evaluations in the Netherlands, Japan and South Korea.
2. The sectoral detail of the complex model is as follows: industry, agriculture, services and government.
3. The spatial detail of the model:
    - for the macroeconomic sub-model: national level
    - for the regional TFP and SCGE sub-models: Hungarian counties (NUTS 3 level)
4. Data need:
    - for the macroeconomic sub-model: time series data from 1990 (for several variables only from 1995);
    - for the TFP sub-model: panel space-time data for 1997-2003
    - for the SCGE sub-model: cross sectional data for 2003 (short run) and time series data for selected variables (long run)
5. The model system is supported by a user-friendly Windows interface that makes policy simulations easy to perform without being familiar with the softwares (Eviews, Excel) applied in executing ex-ante evaluations.

The complex model exhibits the following most important unique features as compared to more traditional approaches in policy modeling:

1. The model has a strong *supply side orientation* besides having a well developed demand side block.
2. *Modeling technological change* is at the heart of the supply side block. The reason for this is that most of the development policy instruments (R&D support, infrastructure investment, education/tranining promotion) aim towards improving firms' productivity.
3. The effect of *static and dynamic agglomeration externalities* in technological change are directly modeled in the complex system. This feature is perhaps the one that distinguishes our approach from others the most. As a result our model is capable of estimating the likely effects of policy scenarios with different spatial distribution of development support both in the short run as well as in the longer run.
4. The complex model provides rich information for policy analysis on the likely effects of interventions not only at the *macro* but also at the *regional* levels. This information is communicated via tables, figures and maps.
5. Finally, despite its highly complex structure the system is "packaged" in a *user friendly Windows interface* that makes policy simulations extremely easy even for those who are not familiar with any of the softwares running in the background.

Since the most distinguishing feature of our modeling approach is that it directly incorporates the geographic dimension of development policy interventions we call this model **G**eographic **M**acro and **R**egional model for Hungary and refer to it as the GMR-Hungary model.

The Consortium that has built this model consists of the following institutes:

- ***Center for Research in Economic Policy*** (GKK, University of Pécs, Faculty of Business and Economics) – project coordination, TFP sub-model-building, planning, integrating and executing the complex model system. (Attila Varga, Péter Járosi, Zsolt Uderszky)
- ***Center for Applied Economic Research Münster*** (CAWM, University of Münster) – macroeconomic sub-model building, planning the complex model system. (Hans Joachim Schalk, Onno Hoffmeister)

- ***TNO*** (Delft) – provision of RAEM-Light for adaptation it to Hungarian circumstances, expert help during calculations of transportation cost matrices, consultancy during the adaptation of RAEM-Light (Lory Tavasszy)
- ***TRANSMAN Ltd.*** – calculation of transportation cost matrices (János Monigl, Zoltán Újhelyi)
- ***Department of Education Management*** (University of Pécs) – designing and developing Windows interface (Balázs Marján)

Scientific advisors on the project:

- Atsushi Koike (Tottori University, Japan) – adaptation of RAEM-Light to Hungarian circumstances (developing RAEM-Light Hungary), expert help during the integration of RAEM-Light into the complex model system
- Tamás Révész (Budapest Corvinus University) – consultancy during the integration of RAEM-Light Hungary into the complex model system.

This report provides the theoretical background for the complex model, a detailed description of the whole system and also an application to assess the likely economic impacts of the Hungarian National Development Plan II (2007-2013).

2. A key issue in development policy analysis: Appropriately modeling technological change and macroeconomic performance

2.1 Development policy and technological change: An empirical modeling framework

Beginning in the early 1980's first in the USA then in Europe and in other parts of the Word new types of development policy instruments emerged both at central and regional government levels. These policies are commonly called "technology-based" (or "knowledge-based") economic development policies. The common aim of these interventions is to improve firm's technological opportunities (Isserman 1994, Cohen, Florida and Goe 1994, Coburn 1995, Reamer, Icerman and Youtie 2003). These policies are clearly related to the fact first proven by Robert Solow (1957) that technological change is the most important component of long-run economic growth. The new set of policies is also influenced by the experience of some highly successful regions (such as the Silicon Valley and Route 168 in the USA, or the Cambridge Phenomenon in the UK) where indigenously developed technologies constituted the principal drive of economic growth (Varga 1998).

Instruments promoting technology-based development can be classified into two sets. Interventions in the first class directly promote firm's technological potential by start-up and investment supports, tax credits, low interest rate loans or venture capital. The second set of instruments affects firms indirectly by supporting the technological (or knowledge) environment by means of R&D promotion both at universities and private firms, human capital improvement, support of public-private interactions in innovation (e.g., university-industry technology centers, government-industry consortia, university-industry research collaboration) or by financing physical infrastructure building[1].

Theoretical foundation of the two sets of policies has been developed in the so-called "innovation systems" literature (Lundval 1992, Nelson 1993, Braczyk, Cooke and Heidenreich). According to this approach innovation is an outcome of a systemic process where interactions among the actors lead to the change of technologies. Actors of the system are innovating firms, their suppliers and buyers, private and public research laboratories, universities, business services active in innovation (such as software, design, marketing or

[1] For a systematic overview of the subject see Reamer, Icerman and Youtie 2003

patent law firms) and different levels of governments. Since innovation is not any more a result of lonely inventors' independent efforts (such as of the Edison-type inventors one hundred years ago) the intensity of interactions among the actors in a system is crucial. Interactions can either be formally or informally organized that is they might be regulated by market forces (and as such these interactions are governed by written contracts) or they could follow the web of personal relations (i.e., interactions are coordinated by the principle of reciprocity). Also, some of the interactions result in knowledge spillovers where the cost to obtain knowledge is zero or less than the value of that knowledge. Innovation systems are classified by industrial sectors (e.g., biotechnology, electronics or software innovation systems) and by spatial units (global, national, regional or local systems of innovation).

The geographical dimension can become crucial in technological change and economic growth for three main reasons. First, because the role of space might be essential in accessing knowledge, second, since agglomeration can be determinant in the accumulation of technological knowledge and third, because of the cumulative growth mechanisms these agglomeration economies initiate.

Spatial pattern of knowledge-related interactions has become a central research issue in the last decade. A series of papers (e.g., Jaffe, Trajtenberg and Henderson 1993, Audretsch and Feldman 1996, Anselin, Varga and Acs 1997, Varga 2000, Keller 2002) demonstrates that a significant fraction of knowledge flows is bounded spatially. A specific characteristic of knowledge communication explains this observation. The effectiveness of knowledge transmission in space seems to be directly related to the degree of codification. While codified knowledge can easily be transported over large distances in written forms (e.g., in scientific papers, patent documentations) transmission of tacit knowledge (non-codified, practical knowledge essential in innovation) relies on more complex, non-written types of communication that require personal interactions. Thus, access to this knowledge might be limited to those only who locate in the proximity of the knowledge source and as such spatial proximity of the actors in innovation could increase the effectiveness of technological change. Geographical proximity may also ease maintaining connections between firms, private and public research institutions and also with business services as it speeds up information flows or helps build trust and the common language of communication (Koschatzky 2000).

Agglomeration is the second geographical aspect of innovation. As an increasing body of literature (e.g., Feldman 1994, Fujita and Thisse 2002, Varga 2000) indicates there is a positive relationship between agglomeration and technological development. Various agglomeration effects such as the positive impact of increasing spatial concentration of researchers on tacit knowledge flows or the positive influence of the size of the local economy (number of related firms, producer services) on localized knowledge interactions are identified in this literature. Thus the larger the concentration of the actors of the innovation system in space the higher the opportunity of forming interactions and the higher the level of innovation. As a result of this agglomeration effect, innovation activities follow a definite tendency to concentrate in space as was demonstrated by Varga (1999) for the US and by Caniels (2000) for the EU.

If spatial proximity is essential in the change of technology and agglomeration forces decrease the costs of innovation these could possibly release a cumulative process of spatial concentration of the system. As such lover costs of innovation attracts firms into the region that further decreases the costs of innovation (at least until positive agglomeration effects dominate) and this effect is strengthened by further firm re-locations. Thus agglomeration forces are crucial in technological change and as such in economic growth explanation.

It directly follows from the above paragraphs that adequate modeling of the impact of development policies on the economy should consider the geographical aspect directly and as such, correct analysis of the effects of various development policy instruments has to be done in the spatial context. What could be the theoretical basis for such an empirical modeling?

Unfortunately it is a very complex task to integrate spatial structure into economic growth explanation. At this point no unified theory is available. As far as I understand the state of the art given the extreme complexity of the problem formal modeling might no even be possible at least with the instruments currently available. Even for empirical treatment research should use a mixture of tools and as such the suggested set of methodologies is eclectic. Consequently, it is important to emphasize that I do not aim to develop a formal theoretical model here. The aim of the proceeding paragraphs is to outline a framework that can guide empirical modeling[2].

[2] For more details see Varga (2006)

Essential elements of this "geographical growth explanation" are rooted in three separately developed recent literatures (Acs and Varga 2002): the endogenous growth theory (Romer 1990, Aghion and Howitt 1998), the systems of innovation school (Lundvall 1992, Nelson 1993), and the new economic geography literature (Krugman 1991, Fujita, Krugman and Venables 1999, Fujita and Thisse 2002). This section provides a framework to integrate elements of these three approaches in a consistent manner to guide empirical research in the field of geographical innovation and growth.

The three approaches focus on different aspects but at the same time are also complements of each other. The "new" theories of growth endogenize technological change and as such interlink technological change with macroeconomic growth. However, the way technological change is described is strongly simplistic and the economy investigated gets formulated in an a-spatial model. On the other hand, systems of innovation frameworks are very detailed with respect to the innovation process but say nothing about macroeconomic growth. However, the spatial dimension has been introduced into the framework in the recently developed "regional innovation systems" studies (e.g., Braczyk, Cooke, Hedenreich 1998, Fischer 2001).

New economic geography models investigate general equilibrium in a spatial setting. This means that they provide explanations not only for the determination of equilibrium prices, incomes and quantities in each market but also the development of the particular geographical structure of the economy. In other words, new economic geography derives economic and spatial equilibrium simultaneously (Fujita, Krugman and Venables 1999, Fujita and Thisse 2002). Spatial equilibrium arises as an outcome of the balance between centripetal forces working towards agglomeration (such as increasing returns to scale, industrial demand, localized knowledge spillovers) and centrifugal forces promoting dispersion (such as transportation costs). Until the latest developments in recent years new economic geography models did not consider the spatial aspects of economic growth. However even in the recent models explanation of technological change follows the same pattern as endogenous growth models and as such fail to reach the complexity inherent in innovation systems studies.

As was detailed above the idea behind the innovation systems approach is quite simple but as such extremely appealing. According to this in most cases innovation is a result of a collective process and this process gets shaped in a systemic manner. The effectiveness (i.e., productivity in terms of number of innovations) of the system is determined by both the knowledge already accumulated by the actors and the level of their interconnectedness (i.e., the intensity of knowledge flows). Ability and motivations for interactions are shaped largely by traditions, social norms, values and the countries' legal systems.

To develop an empirical modeling framework of geographical growth explanation I extend the endogenous growth model in Romer (1990) to the spatial dimension by accounting for insights from the innovation systems literature and then dynamize it by incorporating features of the new economic geography. For a bit more formal treatment I apply the generalized version of the Romer (1990) equation of macroeconomic level knowledge production developed in Jones (1995)[3]:

$$dA = \delta \, H_A^{\lambda} \, A^{\varphi},$$

where H_A stands for human capital in the research sector working on knowledge production (operationalized by the number of researchers), A is the total stock of technological knowledge available at a certain point in time whereas dA is the change in technological knowledge resulted from private efforts to invest in research and development. δ, λ and φ are parameters.

Technological change is generated by research and its extent depends on the number of researchers involved in knowledge creation (H_A). However, their efficiency is directly related to the total stock of already available knowledge (A). Knowledge spillovers are central to the growth process: the higher A the larger the change in technology produced by the same number of researchers. Thus macroeconomic growth is strongly related to knowledge spillovers.

Parameters in the Romer knowledge production function play a decisive role in the effectiveness of macro level knowledge production. The same number of researchers with a similar value of A can raise the level of already existing technological knowledge with significant differences depending on the size of the parameters. First, consider δ ($0<\delta<1$)

[3] The functional form corresponds to the Jones (1995) version, however, the interpretation of λ and φ is different in this paper.

which is the research productivity parameter. The larger δ the more efficient H_A is in producing economically useful new knowledge.

The size of φ reflects the extent to which the total stock of already established knowledge impacts knowledge production. Given that A stands for the level of codified knowledge (available in books, scientific papers or patent documentations) I call φ as the parameter of codified knowledge spillovers. The size of φ reflects the portion of A that spills over and as such its value largely influences the effectiveness of research in generating new technologies.

λ is the research spillover parameter. The larger λ the stronger the impact the same number of researchers plays in technological change. In contrast to φ and δ that are determined primarily in the research sector and as such their values are exogenous to the economy λ is endogenous. Its value reflects the diffusion of (codified and tacit) knowledge accumulated by researchers. Diffusion depends first on the intensity of interactions among researchers (H_A), second the quality of public research and the extent to which the private research sector is connected to it (especially to universities) by formal and informal linkages and third the development level of supporting/connected industries and business services and the integration of innovating firms into the system via links to them. The extensive innovation systems literature evidences that the same number of researchers contribute to different efficiencies depending on the development of the system. In the Romer equation this is reflected in the size of λ.

λ is also sensitive to the spatial structure of H_A. Insights from the new economic geography can help understand the dynamic effects of the spatial structure of R&D on macroeconomic growth. If spatial proximity to other research labs, universities, firms and business services matter in innovation firms are motivated to locate R&D laboratories where actors of the system of innovation are already agglomerated in order to decrease their costs to innovate. Thus spatial concentration of the system of innovation is a source of positive externalities and as such these externalities are centrifugal forces in R&D location. However, agglomeration effects could be negative as well. Increasing housing costs and travel time make innovation more expensive and might motivate labs to move out from the region. The actual balance between centrifugal and centripetal forces shapes the geographical structure of the system of innovation. Through determining the size of λ this also influences the rate of technological progress (dA/A) and eventually the macroeconomic growth rate (dy/y).

Equations (1) to (6) summarize the empirical modeling framework of geographical growth explanation. Equation (1) describes the relationship between innovation output (K) and regional inputs to innovation in region r: private research (RD), public/university research (URD) and the additional actors of the regional system of innovation such as business services, related/connected firms as summarized in variable Z:

(2.1) $$K_r = K\,(RD_r, URD_r, Z_r).$$

A significant relationship between RD and K reflects the importance of geography in innovation and eventually in economic growth. Equations (2) to (6) actually model this relationship.

The regional effect of an increase in private R&D on innovation depends on research already in the region as well as on the presence of additional innovation inputs, URD and Z (agglomeration forces in innovation):

(2.2) $$\partial K_r/\partial RD_r = F\,(RD_r, URD_r, Z_r).$$

Parameters of RD, URD and Z are determined by several factors exogenous to the economy such as the willingness to cooperate in innovation, the structure of research expenditures at universities, local regulations and so on. The marginal effect of R&D on innovation reflects agglomeration economies/diseconomies in innovation and as such affects R&D location:

(2.3) $$dRD_r = R(\partial K_r/\partial RD_r).$$

Positive effects (agglomeration economies) act as centripetal forces whereas negative effects (agglomeration diseconomies) are centrifugal forces in R&D location. The spatial distribution of R&D is determined by regional differences in the marginal effect of research on innovation. In spatial equilibrium $\partial K_r/\partial RD_r$ is the same for all the regions and $dRD_r=0$.

Geographical structure of research (GSTR(H_A)) determines λ:

(2.4) $$\lambda = \lambda\,(GSTR(H_A)),$$

where $H_A = \Sigma_r RD$.

The rest of the equations are from the Romer-Jones model are as follows:

(2.5) $dA = \delta H_A^{\lambda} A^{\varphi}$,

(2.6) $dy/y = H(dA, Z_N)$,

where dy/y is macro level per-capita growth rate and Z_N is additional variables of the model (not detailed here).

Equations 1-6 appropriately situate different economic development policies in the system of causal relations ranging from geographically mediated knowledge production to macroeconomic performance. Some of the policy measures affect the level of knowledge present in the system of innovations such as R&D support at private and public institutions education promotion at all levels (represented in equation 1). Other policies affect the strength of centripetal and centrifugal forces determining the dynamism described in equations 2-3. Such policies include infrastructure financing (rail and road connections, telecommunication networks) that diminishes transport costs and increases accessibility of the region and as such decrease centrifugal forces. Other policies such as supporting interactions among the actors of a system of innovations, promoting entrepreneurship, changing the legal systems (patenting, intellectual property law, licensing technologies from public institutions etc) are also instrumental in strengthening the centripetal forces in the system.

The above set of equations can drive empirical research in development policy modeling. Such a model should explicitly treat the geography of technological change in a dynamic manner to account for various cumulative processes inherent in macroeconomic growth explanation. Based on the above equations the following sub-modeling tasks should be involved:

1. Explicit modeling of the geographical aspect of technological change (equation 2.1);
2. Modeling of agglomeration economies and the resulting cumulative spatial processes (equations 2.2 to 2.4) in knowledge generation;

3. Modeling the macroeconomic effects of geographically explained technological change (equations 2.5 and 2.6).

Current econometric models widely used in development policy analysis such as the HERMIN model in Europe (Bradley, Whelan and Wright 1995, ESRI 2002) or the REMI model in the United States (Treyz 1993, Fan, Treyz and Treyz 2000) have moved into the direction of incorporating geography and technological change into their basically demand-driven systems, however, they are not yet fully developed according to the criteria listed under points 1 to 3 above. On the other hand EcoRET (Schalk and Varga 2004) directly incorporates the geographic dimension via a version of equation 2.1, but the dynamic manner space contributes to macroeconomic performance is not modeled there.

In our complex macro and regional model we account for all the above three aspects in three interconnected sub-models. Modeling the geographical aspect of technological change is accomplished via the regional TFP sub-model (chapter 3), modeling agglomeration economies and the resulting cumulative spatial processes is incorporated by a spatial computable general equilibrium (SCGE) sub-model and the macroeconomic effects are modeled by a macroeconometric sub-model.

2.2 Macro and regional impacts of CSF development policy instruments[4]

The main purpose of the complex macro and regional model is to serve as a tool for ex-ante evaluating the likely economic effects of different scenarios for spending Structural and Cohesion Funds resources as part of the Hungarian National Development Plan II. In this section the mechanisms by which the different CSF policy measures affect the economy in our modeling framework is outlined.

According to their different effects on relevant economic variables the instruments of CSF policy can best be classified into three broad categories:

- CSF support for infrastructure
- CSF support for human resources (education/training and R&D)

[4] This section draws on section 2.3 in Schalk and Varga (2004)

- CSF support for productive structures (private investments)

These instruments are intended to influence the supply side of an economic system primarily, but, intended or not, they also have effects on the demand side. A classical example is the support for private investments that stimulate the productive capacity and investment demand simultaneously. Thus, in order to catch mutual and feedback effects between both sides of the economy a complete analysis of the effects of CSF has to consider their impacts both on the supply and the demand side and their interdependencies as well. The distinction between demand side and supply side effects is also important, because the former impacts are normally transitory while impacts of the latter are enduring. This will be of great interest when testing the impacts of the different policy instruments of CSF.

Because the main objective of EU regional policy is to stimulate growth in the less developed regions to achieve convergence (in output or income per capita), special efforts have to be made to associate CSF interventions to their long-run impacts on output and productivity respectively. Another important goal of EU regional policy is to increase employment and reduce unemployment. It is a priori uncertain whether this target can be achieved with the investment programs of CSF even if they are successful with regard to the growth goal. If technology (efficiency of production) is improved by the CSFs, a desired effect, less labor will be employed at any given level of output. Therefore, it depends on the magnitude of the growth effect of output whether the employment target can also be reached or not. However if labor costs are low relative to the cost of capital (as it is still the case in Hungary), such growth effects could be labor intensive and create plenty of employment. To evaluate CSF impacts correctly, therefore, it is necessary to take care of these effects properly with our analytical methods.

Figures 2.1 and 2.2 intend to give some additional help to describe our method in evaluating the CSF interventions in some more details. First we look at aid that is to stimulate private investment and second at the impacts of infrastructure improvements, R&D and human capital formation. Figure 2.1 illustrates the way the EU aid for private investments can be evaluated within our analytical framework. To keep things clear, the flowchart describes the economic logic and mechanisms of some core relationships of the more complex analytical framework. Moreover, not all explanatory variables have been included. The consequence of

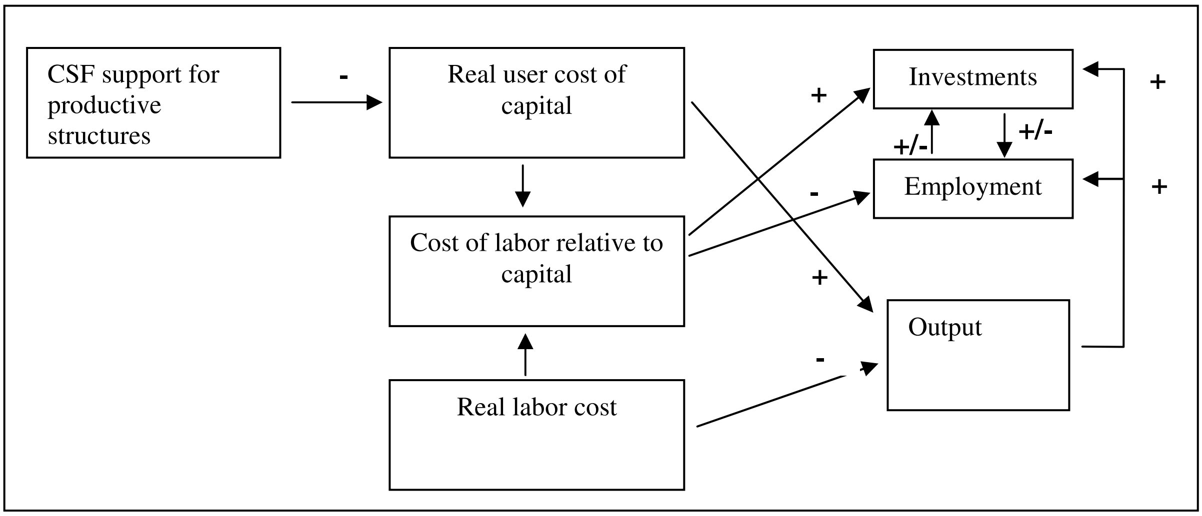


Fig. 2.1: Impacts of CSF support for productive structures

this is that only primary supply side effects on employment, investment and output growth can be outlined here.

Based on theoretical considerations it is the factor price ratio (i.e., the user costs of capital relative to the labor costs), which affects factor demands. Because CSF support for productive structures decreases this ratio, it affects investment positively but labor demand negatively: when labor becomes relatively more expensive than capital, a certain increase in output is produced more capital intensively, that is with less labor.

This undesirable substitution effect of private investment support may be compensated for by an output effect, which is also shown in Figure 2.1. An output effect arises because of two reasons. First, the CSF investment support reduces total production costs for all firms already located in the assisted region (Hungary) inducing them to expand production and purchase more of all inputs. Second, the location of new production capacities in Hungary depends upon an international comparison of the input prices by investors. Those countries, whose comparative cost advantages prevail, attract them. Therefore, the capital user cost differentials between assisted Hungary and non- (or less-) assisted regions in Europe will stimulate investors in the latter regions to shift production into Hungary (foreign direct investments), giving rise to an additional increase in capital and labor demand. Thus the output effect leads to more employment. Therefore, the fact whether CSF private investment incentives eventually increases or decreases labor demand depends on the sizes of the substitution and output effects. Employment will rise only if the output effect outweighs the substitution effect. A reliable assessment of the impacts of the investment support requires a macro-model, therefore, in which these mechanisms are properly specified.

In Figure 2.1 also the effects of labor costs on factor demand and growth can be illustrated. As can be seen, the positive impact of CSF support for productive structures on investment explained by the substitution effect is higher, if wages are increased at the same time. But the overall effect on investment can still be lower, because the higher wages go against the output effect. That is, despite lower user costs, otherwise possible investments from abroad are deterred. Thus, the positive employment and growth effects of CSF may be destroyed completely by wage increases. With our framework it is possible to isolate these effects caused by different policies and to ascribe them to the factor that is responsible for them.

For analyzing the impacts of CSF support for infrastructure and human resources we draw on insights in growth accounting (Barro 1998). This breaks down economic growth into components associated with changes in factor inputs and improvement of technology or „Total Factor Productivity" (TFP) growth. TFP is the channel by which the CSF investments in human capital and public infrastructure can be incorporated and their impacts on growth and other variables analyzed within our model framework.

TFP reflects technological progress and other elements. Recent econometric research for West German and USA regions show that the industrial structure, the age of the capital stock, agglomeration effects, innovation potential and also infrastructure and human resources (qualification of the labor force) are all related to TFP (Schalk, Untiedt 1996, Varga 2000). As depicted in Figure 2.2, improvements to basic infrastructure increases the productivity of capital, and an increase in the quality of labor force by human resource investment improves the efficiency of this factor. Thus, the CSF policies act as if firms used more productive capital at no cost or, alternatively, as the factor inputs actually used were available at lower production costs. Combined together, these effects improve competitive advantage, which lead to higher attractiveness of Hungary, more inward investment in production capacity (foreign direct investment) and growth. Again, the impact on employment is inconclusive. However, the output and income effects (not shown in Figure 2.2) should be sufficiently large to offset the labor shedding effects. The effect on growth is unambiguously positive.

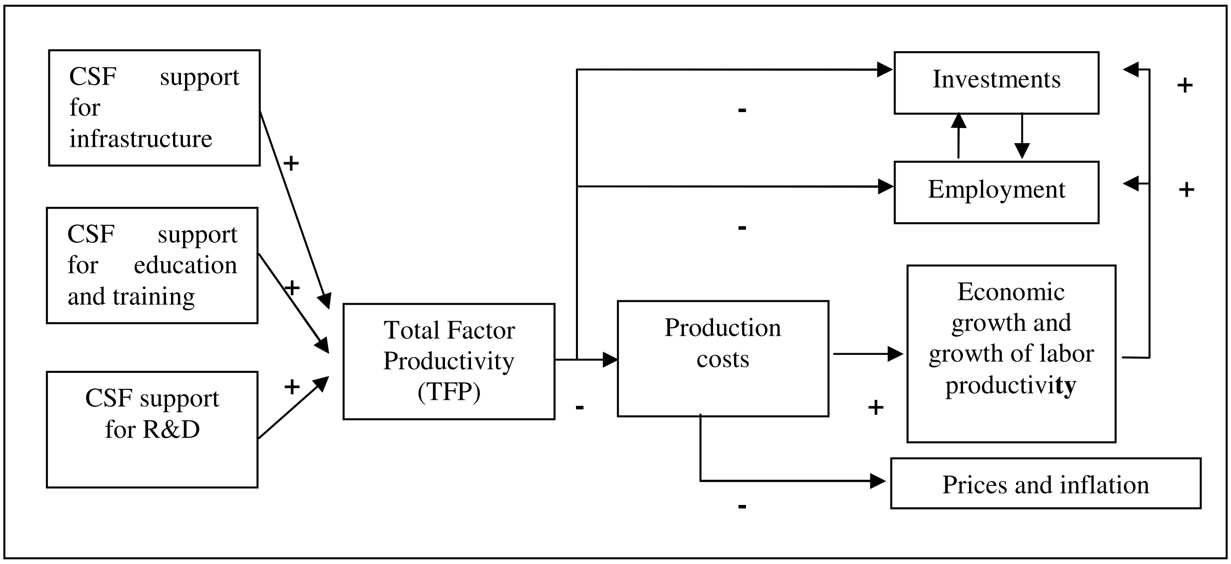


Fig. 2.2: Impacts of CSF support for infrastructure and human resources

The advantage of our approach is that it captures the channels through which even temporary CSF supply-side oriented programs have the intended permanent effects in a proper way. A temporary financial support rise TFP and increases productivity and income per capita to a permanently higher level, while the Keynesian demand-side effect on output and income tapers off (this effect is not considered here).

The two sets of policies (i.e., investment support and infrastructure and human resources targeting) exhibit different geographical features. Investment support (formulated in our model as tax credit) displays no specific spatial characteristics assuming that those measures are applied with no geographic restrictions. However for modeling the second set of interventions the effects of geography should explicitly be accounted for as these measures influence technological change. As such, in the complex model support for productive structures appears in the macro sub-model only whereas support for infrastructure and human resources is modeled in the TFP and SCGE sub-models before they enter the macroeconomic model part.

3. Regional impacts of CSF development policy interventions on productivity: The TFP sub-model

The supply side effects of infrastructure investment and expenditures on education/training and R&D work via increasing Total Factor Productivity (Figure 2.2). Thus finding an appropriate solution for modeling the effects of these CSF instruments on TFP and linking the changes in TFP into the macro-econometric model to study the impact on several macroeconomic variables is crucial in evaluating the effects of the Hungarian National Development Plan. One of the central aims of this research project was to establish the TFP block that can suitably serve these aims.

However, previous empirical research provides little help in this respect. Studies in this area focus either on the effect of human capital on economic growth (e.g., Tallman and Wang 1992, Fukuda and Toya 1994, Mulligan and Sala-i-Martin 1995, Lee and Lee 1995, Gemmell 1996, Fernandez and Mauro 2000, Fuenta and Donenech 2000, Bassanini and Scarpetta 2001) and productivity (e.g., Engelbrecht 1997, Kaufman, Luzio, Dunaway 2001) or on the growth effects of public infrastructure (e.g., Barro 1990, Christodoulakis 1993, Bajo-Rubio and Sosvilla-Rivero 1994, Leigthart 2001) within a single equation framework but not in a macro-econometric model . On the other hand, in traditional macro-econometric models the change in TFP induced by infrastructure investments and human capital expenditures is either not accounted for or if it is of any interest the relevant elasticities are not estimated but calibrated (e.g., Bradley and Untied 2000) .

The solution applied in this study originates in the problem formulation of Acs and Varga (2002) and Varga (2006) as changes in TFP are addressed here in a spatialized macro-modeling framework in which technological progress and economic growth depends to a considerable extent on localized factors. The conceptual basis of this approach is in the new economic geography literature, in the innovation systems literature and in the “new”, endogenous theory of economic growth.

3.1 Empirical implementation

The starting point in empirically modeling changes in Total Factor Productivity is equation (2.5) as originally developed in Romer (1990). Constructing a variable to measure the change in technology is a crucial element in the development and practical implementation of the model. In this respect we followed the solution common in the growth accounting literature (Barro 1998, Barro and Sala-i-Martin 1995). In this literature where the focus is to empirically separate the effects of the changes in capital, labor and technology on economic growth the level of technology is measured as the residual after the contribution of the other two factors of production is accounted for. This residual is called Total Factor Productivity (TFP). Our choice of a regionalized technological change model implies that TFP levels are calculated for each of the spatial units. Thus the empirical counterpart of dA in equation (2.5) is a measure of the change in TFP.

The effectiveness of research in creating new technologies is influenced to a large extent by knowledge spillovers. Romer (1990) assumes that the total stock of knowledge (A) is accessible with no geographical restrictions. However, the recent empirical literature on knowledge spillovers provided sufficient counter-evidence of the Romerian assumption of equal accessibility of knowledge in space. A significant portion of knowledge flows is indeed spatially bounded mainly due to the high level of tacitness in new scientific-technological knowledge. The two types of knowledge are transported by different mechanisms. The perfectly accessible part consists of already established knowledge elements in codified forms and as such it is transmitted via scientific publications or patent documentations. On the other hand the tacit element is accessible most effectively by face-to-face interactions. Additional to the perfectly accessible and the primarily locally available knowledge elements much of knowledge spillovers originate internationally and transmitted by imported products or production processes.

Given that the TFP function is used in CSF policy analyses it is important to accomodate it to such a purpose. As indicated above and illustrated in Fig 2.2 we followed the EC categorization of CSF expentitures. According to this TFP-related expenditures are classified as human capital promotion (education/training and R&D) and infrastructure investment support. In this respect we draw on an extensive empirical literature that studies the extent to which human capital and basic infrastructure effect economic growth (e.g., Barro 1990, Christodoulakis 1993, Bajo-Rubio and Sosvilla-Rivero 1993, Mulligan and Sala-i-Martin 1995, Lee and Lee 1995, Engelbrecht 1997). In our modeling framework this growth effect is channeled via changes in Total Factor Productivity (Schalk and Untiedt 2000).

An important issue to be resolved is determining the exact data coverage of the human capital and infrastructure variables according to the types of expenditures CSF interventions commonly associated with. For the human capital variable it seems quite plausible that expenditures on education and training and R&D should be accounted for there. On the other hand for some types of infrastructure investments (such as transportation, utilities or telecommunications) it is quite natural that they need to be part of the infrastructure variable. However, finding the way expenditures supporting health care is being plugged into the equation needed some considerations. Our solution is based on both theoretical arguments as well as empirical experience. With respect to theoretical base we argue that the health care system works in many ways similar to the infrastructural sector as its service (i.e., workforce in a better shape to be employed) decreases costs of the same size of output very much similar to the way infrastructure investments increase productivity such as constructing new highways. Regarding empirical experience classifying health care in the infrastructural sector is supported first by the fact that most of the support in health care are in the form of investments (contrary to the human capital sector where most of them are expenditures) and second by the fact that health care investment enters the equation significantly only if it is part of infrastructure and not in cases when it is included in the human capital variable in any of the forms we experimented with. Other types of CSF supports most importantly environmental support is decided not to enter the TFP function as these types of expenditures do not seem to be clearly related to the supply side (at least not in the medium run) as their effects are mainly appear on the demand side.

The empirical TFP model has the following form:

$$(3.1) \quad TFPGR_{i,t} = \alpha_0 + \alpha_1 KNAT_t + \alpha_2 RD_{i,t} + \alpha_3 KIMP_{i,t} + \alpha_4 INFRA_{i,t} + \alpha_5 EDU_{i,t} + \varepsilon_{i,t},$$

where

- TFPGR is the annual rate of growth of Total Factor Productivity at the county level,
- KNAT is domestically available technological knowledge accessible with no geographical restrictions (A in equation (2.5)),
- RD stands for private and public regional R&D (H in equation (2.5)),
- KIMP is imported technologies,
- INFRA is investment in physical infrastructure,
- EDU is investment in human capital (education and training),
- ε is the stochastic error term.

In the empirical analyses below we also applied the variable HUMRES which stands for expenditures in education, training and R&D called human resources in the categorization of the EC. According to the theoretical framework outlined in the previous chapter, technological change depends to a large extent on local/regional factors of innovation. Thus the unit of empirical investigation applying equation (3.1) should be some sub-national geographical entity. Since the lowest level of spatial aggregation of the type of data we need for analysis is the county the selected unit of analysis is Hungarian counties. The spatial unit is denoted by i while t stands for time in equation (3.1).

To implement equation (3.1) in an empirical analysis we relied on different data sources. KNAT is measured by the number of patents available in Hungary obtained from the Hungarian Patent Office. In empirical estimations we measured RD alternatively either by R&D employment or by R&D expenditures aggregated from data at private, public and university research institutes. The Hungarian Central Statistical Office provides these data. The measure of KIMP is the share of foreign direct investments in total private investments. To measure foreign direct investments we used data on the number of firms in different size groups and percentage of firms in manufacturing. Data come from regional and county statistical yearbooks published by the Hungarian Central Statistical Office. Investments in infrastructure measure INFRA. Data on infrastructure investments include investments in transportation, telecommunication, health care and utilities. Data sources are regional statistical yearbooks. HUMCAP is measured by all (private and public) expenditures on education and training. Data sources are Hungarian National Accounts by the Central

Statistical Office. All the variables measured in monetary terms are in 1995 Hungarian Million Forints.

To empirically generate a variable measuring the growth in TFP we followed the solution developed in the growth accounting literature (Barro 1998). TFP levels for each county are calculated from a constant returns to scale Cobb-Douglas production function as the residual after the contribution of capital and labor is subtracted from the output[5].

The effects of the different instruments applied in development policy intervention (infrastructure investment, education/training or R&D support) might not stay in the targeted region only but could perhaps spill over to neighboring territories as well. In order to understand if the effects spill over to other regions at all we run tests of spatial dependence in the forms of spatial error and lag on each estimated versions of the TFP equation.

3.2 *Estimation results*

Estimation results of equation (3.1) are presented in Table 3.1. KNAT (stock of knowledge, measured as the number of available patents in Hungary) and RD (R&D expenditures measuring research input in technological development) are the two variables representing the original Romer-approach. While KNAT is significant in all the variants of the equation RD is not when included separately from other human capital expenditures (Models 1 and 3). Out of the potentially important alternative variables measuring the regional innovation environment, KIMP, the share of FDI in total investments turns out to be the most influential for regional technological development. Its parameter enters the equation with the expected sign and also

[5] The production function has the following form: $Y = AK^{\alpha}L^{1-\alpha}$, where Y is regional output measured by regional GDP at 1995 prices, A is total factor productivity, K is capital, L is labor. The value of K is calculated from investment data following the perpetual inventory method (Hall and Jones 1999). The starting value of K in 1995 is calculated using the formula of $I_{95}/(g + \delta)$ where I_{95} is investment in 1995, g is calculated as the average growth rate from 1995 to 2000 of the investment series and δ is the depreciation rate for which (as it is in the macro-econometric model) we assumed the value of 0.10 which is in line with international standards and also used by the OECD in estimation of potential output growth for Hungary (OECD 2000). The values of the parameters in the production function are assumed to be equal to the income shares of K and L (with α is 0.33). To determine the values of TFP we followed the formula of $A = Y/Y'$, where $Y'=K^{\alpha}L^{1-\alpha}$.

Tab. 3.1: Pooled FGLS estimation results for TFP growth rates (TFPGR) and for 20 Hungarian counties, 1996 – 2003

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Final Model
C	-2.5434	-2.4740	-2.4797	-2.4965	-2.2423	-1.8243	-1.0389
	(0.2989)	(0.2910)	(0.2919)	(0.2735)	(0.2728)	(0.2372)	(0.3408)
TFPGR(-2)							-0.2587
							(0.0749)
KNAT (-2)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	8.84E-5
	(2.68E-05)	(2.59E-05)	(2.60E-05)	(2.45E-05)	(2.44E-05)	(2.10E-05)	(3.04E-05)
KIMP (-3)		0.1582	0.1526	0.1455	0.0892	0.1219	0.0826
		(0.0449)	(0.0456)	(0.043)	(0.0430)	(0.0393)	(0.0392)
RD (-2)			1.29E-06				
			(1.77E-06)				
d(INFRA(-1))				3.79E-06	1.46E-06	1.56E-06	2.11E-06
				(9.60E-07)	(1.34E-06)	(9.41E-07)	(8.44E-07)
d(HUMRES(-2))					6.95E-06	4.74E-06	5.63E-06
					(2.84E-06)	(2.47E-06)	(2.41E-06)
DUM99						-0.0601	-0.0610
						(0.0081)	(0.0080)
Weighted Statistics							
R^2-adj	0.31	0.37	0.37	0.42	0.42	0.59	0.62
F-statistic	54.02	35.71	23.83	31.15	18.44	29.27	28.36
Prob (F-statistic)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Durbin-Watson stat	1.90	2.06	2.07	2.02	1.68	2.22	2.42
N	120	120	120	120	100	100	100
Unweighted Statistics R^2-adj	0.14	0.19	0.20	0.21	0.23	0.35	0.42
ML Spatial error Neighb							1.25
ML Spatial lag Neighb							3.78*

Note: estimated standard errors are in parentheses it is highly significant and quite stable through all the empirical models presented in Table 3.1. The knowledge stock KNAT affects TFP growth with a two-year time lag. Changes in public infrastructure investments, d(INFRA), and changes of expenditures in education, training and R&D, d(HUMRES), represent the CSF instruments in the empirical model. After structural changes on the time domain is taken care of, the parameters enter the equation with the expected signs as well as with high significances. To increase in-sample forecasting power of the TFP equation we included the lagged dependent variable as well on the right hand side which enters the function with high significance. DUM99 is a year dummy to account for a structural brake in the TFP data.

The size order of the parameters is also in accordance with expectations. The highest coefficient value is given for technology import, KIMP that is not surprising taken into consideration that the crucial role of multinationals in Hungarian technology development is well recognized in professional circles. It might be taken as a good sign that TFP growth rate is affected by the knowledge stock with a relatively high coefficient suggesting an increasing importance of indigenous technological development. Turning to the role of the CSF instruments in TFP growth, spending on education, training and R&D, HUMRES seems to be a more effective instrument (at least in a short and medium run) to influence firms' productivity than infrastructure investments, INFRA. It should be emphasized here that our model (at least at this stage of development that is determined dominantly by data constraints) can capture only short and medium run effects and the inevitable long run impacts of R&D, infrastructure investments as well as education developments are only suggestive here.

Regression fit is good (the adjusted R-square has the value of 0.62 in the final model) taken into account the presence of cross sectional data for a relatively short time period. The overall performance of the equation is also impressive as suggested by the highly significant F-statistics. Given the wide variety in TFP growth rates across counties it is not surprising, that heteroscedasticity is a major issue in estimation. Different econometric modeling approaches have been applied (such as fixed effect model, random effect model, SUR) but the most effective estimation technique (in the sense of regression fit, parameter stability and parameter significances) was Feasible Generalized Least Squares (FGLS) with cross-section weighting and White heteroscedasticity consistent standard errors and variance. The magnitude of the problem of heteroscedasticity in the data is indicated by the significant differences between respective regression fits with and without weighting[6].

Spatial dependence in the final model is non-significant in the form of spatial error and only marginally significant for spatial lag that suggest that the out-of region impact of a development policy intervention is only negligible[7].

Given that the estimated equation in Table 3.1 does serve a highly practical aim of impact analysis it is necessary to relate the size of the estimated parameters of the two policy variables to findings in the related literature in order not to calculate unrealistic policy effects. Since no similar geographical knowledge production function study has been carried out to the best of our knowledge it is not possible to relate the estimated parameters directly to other estimations. However, it is possible to calculate infrastructure and human capital investment elasticities in GMR. We compare those values to findings in the literature. In the followings we rely on the survey made by Bradley, Morgenroth and Untiedt (2000). Our calculated elasticity values are situated well in the range of the surveyed studies[8]. For infrastructure the estimated elasticities in the literature range between 0.1 and 0.8 whereas our calculated elasticity is 0.40. With respect to human capital (education and training) the range in the studies is 0.15-0.40 whereas the GMR elasticity for human resources is 0.30.

The historical forecasting power of the estimated final equation in Table 3.1 is also appropriate considering the aim it serves in the complex model: MAPE (mean absolute percentage error) of forecasting TFP[9] at the national level is 1,87[10] and the correalation

[6] This heteroscedasticity is caused to a large extent by the determining role of Budapest in the Hungarian economy. We also tried to capture the „Budapest effect" by a dummy variable. This variable remained insignificant suggesting that the applied regression technique sufficiently takes care of the heteroscedasticity problem of the data. Fur further discussions on the heteroscedasticity problem caused by the „Budapest effect" and its treatment in knowledge production function-type regression analyses see Varga (2007). Note that according to the Hungarian National Development Plan (2007-2013) the main focus of government support will not be Budapest. As such the funds targeting the capital are relatively small in size and their effects are also not expected to be decisive.

[7] Since the data have both space and time dimensions we also tested for cointegration. The D-W test refused non-cointegration of the data at the 1% significance. The short length of the time series does not allow us to run the Dickey-Fuller test.

[8] For the calculations we used the scenario data provided by the National Development Agency and presented in details in Chapter 7. Elasticities were calculated for each year and then averaged over the planning period.

[9] As will be detailed below the regional TFP equation is used to predict TFP levels at the national level. These TFP levels enter the macro sub-model to produce simulated values of several macro level variables. Macro level TFP is calculated as weighted averages of regional TFP levels (where regional TFP level is the sum of the TFP level at the previous period and the change of TFP predicted by the TFP function). Regional employment is used to weight regional TFP levels. The aim behind weighted averaging regional TFP was to account for the effects of

between observed and predicted TFP levels is 92 percent. Fig. 3.1 depicts observed and predicted TFP levels at the national level.

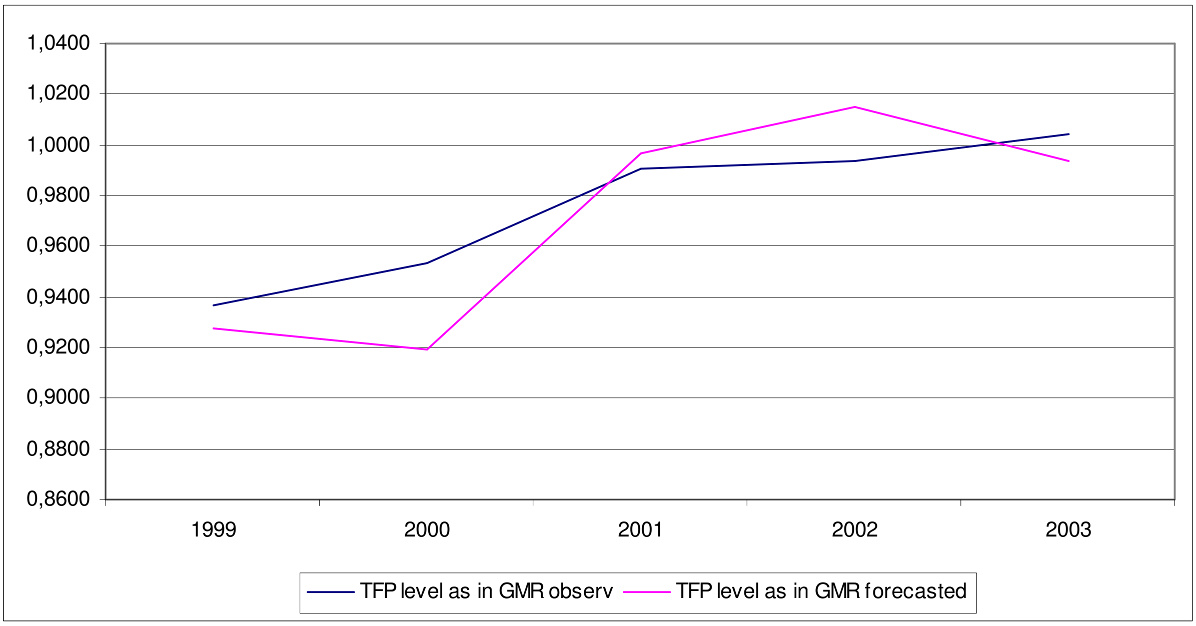


Fig. 3.1: Observed and predicted levels of national TFP

In policy simulations the estimated TFP equation plays a crucial role in the complex model system. Regional values of the policy variables (INFRA, HUMPAC) are plugged into the equation to calculate the likely change in the TFP growth rate. This estimated change in the TFP growth rate enters the SCGE sub-model to generate regional values of TFP levels as a result of agglomeration effects as well as employment, wages, investment and output. TFP levels generated by the SCGE sub-model will then enter the macroeconomic model to account for the macro level outcomes of CSF interventions.

agglomeration in the change of technology (Schalk and Varga 2004). This procedure provides very close estimates of the national TFP level as the MAPE of observed national and calculaetd national TFP levels via weighting regional TFPs is 1.23 percent.

[10] A rule of thumb in practice is that MAPE below 5 percent is considered as the sign of a very good fit.

4. Modeling dynamic agglomeration effects and the resulting cumulative spatial processes: The Spatial Computable General Equilibrium (SCGE) sub-model[11]

To model dynamic agglomeration effects of CSF interventions in the complex macro and regional model a spatial computable general equilibrium (SCGE) model is integrated. CGE models are numerical and empirical applications of Walrasian general equilibrium models in real world circumstances (Hosoe 1999). These models build on usual assumptions in microeconomics (i.e., utility and profit maximization/cost minimization, perfect competition and most recently monopolistic competition). CGE models are especially well suited to simulate the short- and long run impacts of shocks to the system. A particularly attracting feature of these models is that they do not need as many observations and details in the data as more traditional econometric techniques do.

Spatial CGE modeling is a very recent development in empirical research. A couple of examples include Oosterhaven et. al (2001), Thissen (2003), Koike and Thissen (2005). These models are the empirical counterparts of new economic geography systems. Short run SCGE models involve equilibrium in each region whereas in the long run not only each of the regions but also the whole spatial system is in equilibrium as there is no inclination by firms or households to relocate since differences across regions with respect to real incomes disappear resulting from a continuous change in the spatial distribution of economic activities. SCGE models have successfully been applied to simulate regional effects of certain development policies such as highway investment policies both in the short run and in the long run.

The particular SCGE model integrated into our framework is RAEM-Light. This model is a simplified version of RAEM the model for the Netherlands (Thissen 2003). RAEM-Light is particularly suitable in situations when regional data are only scarcely available for several variables necessary in RAEM. Data availability problems constrained the application of RAEM in Hungarian circumstances as well. This explains the decision towards RAEM-Light. This chapter draws on the description of the model in Koike and Thissen (2005). However, the particular form of RAEM-Light incorporated into the complex model system is somewhat different from the one recently applied in the Netherlands and South Korea for policy simulations. It was necessary to adapt the model to Hungarian circumstances on the one hand

[11] This chapter draws on the description of the RAEM-Light model in Koike and Thissen (2005).

and to the requirements of the complex model system on the other. (For details consult the Appendix.) Regarding the second issue especially adaptation to the TFP sub-model required some important changes in the technology part of RAEM-Light.

4.1 Main model assumptions

a. The model considers several regions and also different industrial sectors (20 regions and 4 sectors for Hungary);

b. The model distinguishes between short run (i.e., a period of one year with the assumption that equilibrium at each region is reached at both goods and factor markets) and long run (several years through which the system is attracted towards a spatial equilibrium as a result of factor movements across regions);

c. The total number of households is assumed fixed;

d. Total housing supply is fixed or exogenously determined in each region;

e. Capital and labor are used in production;

f. Iceberg-type transportation cost (i.e., transportation cost is measured as a portion of the good needed to transport the commodity for a given distance);

g. Capital stock is owned by households (national dividend);

h. The model considers both *centripetal* and *centrifugal forces* that form the geographical structure of the economy. Centrifugal forces weaken spatial concentration while centripetal forces work towards further agglomeration. In the model the centrifugal forces are transportation costs and congestion. The level of congestion is measured by per capita housing. As indicated above housing supply is considered fixed in the model consequently increasing population decreases per-capita housing which works against agglomeration. The centripetal force in the model is a positive agglomeration economy measured by the level of Total Factor Productivity in the region. Increasing concentration of economic activities (measured by the level of employment in the model) increases the probability of interactions among the actors of innovation in the region that results in a higher technological level. Thus increasing concentration works towards further agglomeration. The actual balance between centripetal and centrifugal forces in the model determines the migration of labor and capital. As such the spatial distribution of production, TFP and inputs are all determined by the interplay of centrifugal and centripetal forces.

4.2 Data requirement and data sources

RAEM-Light does not need extensive data inputs. The basic information comes from the National Accounts statistics of the Hungarian Central Statistical Office. Value added by sectors is applied to get output values and also (using income shares for calculation) capital and labor inputs. As such, the measure of production inputs is value added. In addition to these population data (Central Statistical Office), stock of housing (number of flats from Central Statistical Office) and transportation costs information are needed. For transportation costs a matrix is required with the iceberg-type values (provided by Transman Kft). Details regarding these matrices are provided in the Appendix. All data are required for one particular year, 2003. Capital rent is set to 1 and equilibrium wages are calibrated.

4.3 The main equations

The production function has a Cobb-Douglas form with capital, labor and technology inputs. To make RAEM-Light suitable for policy simulations in the complex model the following formulation of technology with the regional (i) and sectoral (m) dimensions is introduced

$$(4.1) \qquad A_{i,m,t}\left(L_{i,t}\right) = \zeta_{i,m,t} A' \; L_{i,t}^{\gamma}$$

where A is the level of technology, A' is national "average" level of technology L is regional employment at time t.

$$(4.2) \qquad \zeta_{i,m,t} = TFPSHARE_{i,m}\left(1 + TFPGROWTH\right)^{t}\left(1 + TFPSHOCK_{i,t}\right)$$

where TFPSHARE is the average share of each industry at the county level according to empirical data for the period of 1996-2003. TFPGROWTH is the annual growth rate of technology which is the same as in the macro model, 1.49 percent per year according to the calculations from aggregated regional TFP levels[12].

[12] A very similar value, 1.6 percent was reported for Hungary for the 1990s in Campos and Coricelli (2002). However, in Darvas and Simon (1999) a higher average value, 3.7 percent was calculated for the 1990s whereas Révész ended up with a much lower value, 0.3 percent for the 1999-2003 period.

Development policy interventions (i.e., infrastructure investment, human resources support) resulting in TFP growth changes estimated in the TFP sub-model affect the SCGE model by the variable TFPSCHOCK as depicted in equation 4.2. TFPSHOCK is a change in the annual TFP growth rate resulting from policy interventions. Equations 4.1 and 4.2 formulate the level of technology in a given region/sector at a given time period resulting from policy interventions. This level of technology constitutes the "national average" element (A'), the effect of agglomeration at the particular region (measured by L^{γ} where L is employment and γ is estimated econometrically) and the sectoral element (TFPSHARE). $A'\zeta$ measures the policy effect without considering agglomeration differences across regions. The agglomeration effect is accounted for by multiplying $A'\zeta$ with the term L^{γ}[13].

Interregional demand for goods determines output of the firm and following the principle of cost minimization capital and labor demand is formulated:

4.3 $$L'_{i,m,t} = \frac{a_m}{w_{i,t}} q_{i,m,t} y'_{i,m,t}$$

4.4 $$K'_{i,m,t} = \frac{1-a_m}{r} q_{i,m,t} y'_{i,m,t}$$

where a stands for partial production elasticity of labor, y is output and q is price with no transportation costs included (F.O.B. price):

4.5 $$q_{i,m,t} = \frac{w_{i,t}^{a_m} r^{1-a_m}}{A_{i,m,t} a_m^{a_m} (1 - a_m)^{1-a_m}}$$

where w and r are wage and capital rent and the rest of the notations is as before.

Utility is formulated as a Cobb-Douglas-type function with goods and housing consumption. Utility maximization results in goods demand at sector m:

[13] Both A' and γ are estimated econometrically from the equation: $A = A'L^{\gamma}$. Estimated parameter values are presented in Tab. 4.1. The logic behind this equation is that the level of technology at a given region is partly determined by an "average" (national) component measured by A'. Regional differences are captured by L via the estimated parameter of γ.

4.6 $$x_{i,m,t} = \frac{\beta_m}{1-\alpha} \frac{1}{p_{i,m,t}} \left(l_i \, w_{i,t} + \frac{r\mathbf{K}_t}{\mathbf{N}_t} \right)$$

where **N** and **K are** population and capital at the national level, p is price including transportation costs (C.I.F price). β_m is the share of expenditures spent on good m in the total budget of a consumer.

The probability of trade between region i and j is formulated as follows:

4.7 $$s_{ij,m,t} = \frac{y_{i,m,t} e^{-\lambda_m q_{i,m,t} (1+\tau_{ij,m})}}{\sum_{k=1}^{I} y_{k,m,t} e^{-\lambda_m q_{k,m,t} (1+\tau_{kj,m})}}$$

Interregional trade volume is

4.8 $$z_{ij,m,t} = N_{j,t} x_{j,m,t} s_{ij,m,t}$$

Supply is derived from interregional demand

4.9 $$y'_{j,m,t} = \sum_{i=1}^{I} (1+\tau_{ij,m}) z_{ij,m,t}$$

4.4 Solution algorithm for short run

a. Set r=1 and initial wage w for each region
b. Calculate average cost (q)
c. Calculate the probability of interregional trade (S) and C.I.F price (p)
d. Calculate demand (x) and interregional trade volume(z)
e. Calculate production (y) by 4.9
f. Calculate factor demands (K and L)
g. Check whether labor is in equilibrium if yes, short run equilibrium is reached if not
f. Change w and start from a.

4.5 Long run: the main equations

After a short run (regional level) equilibrium is reached labor starts migrating to places where utility levels are higher according to the following equation:

$$4.10 \qquad L_{i,t+1} = \left(L_{i,t} - \phi \frac{\sum_{i \in I} L_{i,t}}{I} + \frac{e^{\theta(u_{i,t}+c_i)}}{\sum_{i \in I} e^{\theta(u_{i,t}+c_i)}} \phi \sum_{i \in I} L_{i,t} \right) G$$

where I is number of regions G is annual percentage change in labor. Capital movement follows labor migration (according to the assumption of national dividend). Full spatial equilibrium is reached when no inclination for migration arises.

4.6 Parameters: calibration, estimation and application from earlier results

To adapt RAEM-Light to Hungarian circumstances a particular care should have been given to setting parameter values. Some of the parameters are taken from earlier studies/experiences, some of them are estimated econometrically and some of them are calibrated. Table 4.1 provides further details in this respect. Calibration is governed by the principle of getting the best values for several statistics describing the spatial-temporal behavior of the SCGE model (as compared to data of the average values of the variables over the period of 1996-2003). Table 4.2 exhibits these values for the parameter combination chosen. As shown in the table the model is capable of reproducing the spatial-sectoral distribution of the main variables with high precision especially output, labor, investment and population (i.e., the patterns of migration).

Tab 4.1: Setting parameter values in the SCGE model (RAEM-Light Hungary)

parameter	description	type	value
delta	depreciation rate	Taken the same as in the macro model	0.10
alpha	utility function parameter (housing)	based on statistical data	0.2
beta1	utility function par. (sector 1 goods)	Calibrated based on consumption shares	0,355095
beta2	utility function par. (sector 2 goods)	Calibrated based on consumption shares	0,026118
beta3	utility function par. (sector 3 goods)	Calibrated based on consumption shares	0,229658
beta4	utility function par. (sector 4 goods)	Calibrated based on consumption shares	0,189128
fi	migration parameter	calibrated	0,05
theta	migration parameter	calibrated	1
G	labor growth	Annual values are taken from the macro model	
a1	Cobb-Douglas production function (sector 1)	Calibrated based on labor income share	0,4555
a2	Cobb-Douglas production function (sector 2)	Calibrated based on labor income share	0,885274
a3	Cobb-Douglas production function (sector 3)	Calibrated based on labor income share	0,442312
a4	Cobb-Douglas production function (sector 4)	Calibrated based on labor income share	0,683298
lambda1	Transportation parameter (sector 1)	econometrically estimated	23,5
lambda2	Transportation parameter (sector 2)	econometrically estimated	24,3
sigma1	Share of investment (sector 1)	National Accounts data	0,55122
sigma2	Share of investment (sector 2)	National Accounts data	0,13162
sigma3	Share of investment (sector 3)	National Accounts data	0,16956
sigma4	Share of investment (sector 4)	National Accounts data	0,00446
A'	Efficiency parameter TFP	econometrically estimated	0,296959
gamma	Efficiency parameter TFP	econometrically estimated	0,130709

Tab. 4.2: Indicator values to evaluate model performance: The final model

indicator	description	value
Li correlation (spatial)	Labor correlation (regions in country)	0,99666
Lm correlation (sectorial)	Labor correlation (sectors in country)	0,97077
mean Σm **Lim**=1 correlation	Labor correlation (sectors in region)	0,93257
mean Σm **Lim**=1 MAPPD	Labor MAPPD (sectors in region)	3,305%
mean Σi **Lim**=1 correlation	Labor correlation (regions in sector)	0,92202
mean Σi **Lim**=1 MAPPD	Labor MAPPD (regions in sector)	1,131%
Yi correlation (spatial)	Output correlation (regions in country)	0,99695
Ym correlation (sectorial)	Output correlation (sectors in country)	0,98901
mean Σm **Yim**=1 correlation	Output correlation (sectors in region)	0,95923
mean Σm **Yim**=1 MAPPD	Output MAPPD (sectors in region)	3,928%
mean Σi **Yim**=1 correlation	Output correlation (regions in sector)	0,98320
mean Σi **Yim**=1 MAPPD	Output MAPPD (regions in sector)	0,837%
INVi correlation (spatial)	Investment correlation (regions in country)	0,92026
INVm correlation (sectorial)	Investment correlation (sectors in country)	0,98512
mean Σm **INVim**=1 correl.	Investment correlation (sectors in region)	0,91836
mean Σm **INVim**=1 MAPPD	Investment MAPPD (sectors in region)	5,432%
mean Σi **INVim**=1 correl.	Investment correlation (regions in sector)	0,79969
mean Σi **NVim**=1 MAPPD	Investment MAPPD (regions in sector)	1,723%
wi correlation (spatial)	Wages correlation (regions in country)	-0,24169
wi MAPPD	Wages MAPPD (regions in country)	14,624%
Ni correlation (spatial)	Population correlation (regions in country)	0,99679
Ni MAPPD	Population MAPPD (regions in country)	0,105%

MAPPD = Mean Absolute Percentage Point Difference

5. Macroeconomic impacts of CSF development policy interventions: The macroeconomic sub-model[14]

5.1 Data, estimation and calibration

The Appendix contains the full equation system of the model. In this section we confine ourselves to the presentation of the characteristic features of the model in the light of its main economic and technical relationships. A brief discussion of background theory is given, the specification of the mathematical forms of the model equations derived, the estimation of the coefficients performed and finally the forecasting ability of each calibrated function illustrated. Data sources are the Eurostat AMECO database as well as the Hungarian Central Statistical Office (National Accounts). For details consult the Appendix. Because of the strong structural breaks and changes in the first years of the transformation process, for some variables data prior to 1995 have not been very reliable for econometric estimation. Besides, due to the small number of observations available, sophisticated methods and techniques commonly used for econometric estimation and hypothesis testing were either inappropriate or not feasible. Therefore, the parameterization of some behavioral equations has to be performed by way of *indirect* calibration. How we proceeded in these cases is explained in more detail in the following at the respective places.

5.2 Employment and investment

The theoretical underpinnings of the factor demand equations (labor and capital demand) for the business sector, which belong to the supply block of the model, follow the neoclassical theory of the firm. This is an entirely conventional specification also used, i.e., in the modeling of the supply side of the seven major OECD economies in the INTERLINK model (see Turner, Richardson, Rauffet 1996) and in Schalk, Untiedt (2000). According to this theory, factor demands are determined above all by factor costs for labor and capital and the technology of the underlying production function. Despite of similar theoretical frameworks adopted, however, varying factor demand relationships are obtained, depending on two

[14] This section updates section 3 in Schalk and Varga 2004.

different key assumptions made in both model types. The first concerns the form of the underlying production function and the second the economic behavior of the firms (profit maximization or cost minimization).

In our approach it has been assumed that the firm's choice of production techniques can be represented by a vintage capital production function in which capital is viewed putty-clay, i.e. ex-ante substitutability between capital and labor is assumed but fixed ex post proportions after capital installation. If IPV represents machines respective private gross investment that are combined with labor employed on these machines, ΔETB, to produce the desired increase in gross output of the business sector, ΔGDPBV, the ex-ante production function can be written in its general form as (see Schalk, Untiedt 2000 for details):

5.1 $\Delta GDPBV = f_1(\Delta ETB \cdot ELEFFU, IPV)$

ELEFFU is a technology parameter, which reflects the *efficiency of labor*. Firms in a country may be less efficient than in others due to a lack of infrastructure and human capital, lower private capital formation which incorporates the newest technology, a shortage of innovative firms, low competitiveness, unfavorable industrial structure, etc. Thus, the explicitly introduction of ELEFFU into the model creates one of the channels through which the long-term supply side effects of CSF measures for enhancing infrastructure, human resources and private investment can be analyzed. These measures bring about an improvement in the efficiency of labor or *technology* of production in the broadest sense, thus increasing long-term growth of productivity and output in the economy.

Regarding the optimization behavior of the firm cost minimization is assumed, that is, considering the putty-clay production technology, firms decide on a certain output increase in each period and minimize the cost of producing this production increment. Combining this condition with the assumed production function leads to a joint factor demand system, which can be written in the following general form:

(5.2) $IPV = f_2(\Delta GDPBV, WSSE/UCC, ELEFFU)$

$$(5.3) \qquad \Delta ETB = f_3(\Delta GDPBV, WSSE/UCC, ELEFFU)$$

WSSE is the wage rate and UCC represents the user cost of capital. This factor demand model has some striking properties which differ considerably from that of the OECD-INTERLINK, where in contrast to our model profit maximization behavior and a putty-putty production technology have been assumed, i.e. the capital stock is malleable ex-ante and ex post:

- Investment and also changes of employment do not depend on *changes* in the capital-labor cost ratio, as is the case in a factor demand model based on a putty-putty production technology. With a putty-clay production function it is the *level* of the input cost ratio, which produces a *change* in capital and employment.

- It is the relative factor prices (labor cost in relation to the user cost of capital) that determine factor demand in both equations and not the absolute factor costs as in the profit-maximizing model. In the investment function a positive sign for the influence of a relative factor price change is expected, in the labor demand function a negative sign. Therefore, a reduction in the user cost of capital relative to labor, i.e. evoked by the private capital supports of CSF policy, increases investment demand but decreases employment. This substitution effect of a change in the factor price ratio is accounted for in our approach but excluded by assumption in the OECD-INTERLINK model.

- By means of the underlying production function, the technology parameter ELEFFU has also been introduced into the factor demand functions. The impact of ELEFFU is expected to be negative in both factor demand equations: higher efficiency reduces capital and labor input needed to produce a given output. Therefore, if technology is improved by CSF policy, a desired effect, less labor will be employed, thus violating the employment target. But this is true only if production remains constant. Higher efficiency also lowers factor costs, which increases competitiveness and leads to higher output growth and this, in turn, increases factor demands. In the OECD modeling, only this latter effect of ELEFFU on the demand for capital and labor is captured. To capture it in our model an additional equation is needed which links efficiency to growth.

Such an equation is also necessary to model the output effect of factor price changes properly, because equations (2) and (3) can only take account for their substitution effects. An output effect, i.e. caused by the reduction of the user cost of capital as a result of CSF investment subsidies, may arise for the reasons discussed in the preceding section. By means of an output equation, all these discussed impacts of the factor prices on output growth are captured.

The calibration of the factor demand equation system (5.2) and (5.3) is performed in following steps:

- In the first step, the interrelated factor demand system is derived consistently from a joint optimization process (cost minimization) under an explicit specified form of the production function.

- In a second step, the factor demand functions, whose coefficients can be constructed from the elasticities of the underlying production function, are "indirectly" calibrated by econometric estimates of the production function.

- In a third step, a lag structure is quantified in order to introduce some dynamics into what up to this point has been basically the specification of a static model in equilibrium. Thus the short-term dynamics and long-run behavior of the model system are taken into consideration simultaneously. Because of the data problem, only simple lag structures can be modeled.

- Finally, the remaining parameters are estimated with the available historical data.

As for the production technology it is assumed that the business sector output is determined by a Cobb-Douglas production function with constant returns to scale. In the putty-clay technology or vintage-capital version this function can be written as:

5.4 $\Delta GDPBV = (\Delta ETB \cdot ELEFFU)^{XTAU} (IPV)^{1-XTAU}$

XTAU is the elasticity of output with respect to labor and labor efficiency, ELEFFU, represents labor augmenting technical progress.[15] This production function type (but not in its vintage-capital version) has also been adopted in the OECD-INTERLINK sub-models for the seven major OECD member countries. It is also used in other empirical research works upon which we draw in the following for calibrating the coefficients of the factor demand equations. Consistent with this production technology and assuming cost minimization, the desired investment and labor demands are given, in log-linear form and ignoring intercept terms (which is done throughout the following analysis), as:

5.5 $\log IPV = XTAU \log(WSSE/UCC) + \log\Delta GDPBV - XTAU \log ELEFFU$

5.6 $\log\Delta ETB = (1 - XTAU) \log(WSSE/UCC) + \log\Delta GDPBV - XTAU \log ELEFFU$

Before calibrating these equations various methodical problems need to be solved and some approximations have to be made to obtain manageable equations. First, labor efficiency, ELEFFU, which is not an observable variable, is substituted by the expression:

$$\log ELEFFU = \lambda \, TIME$$

TIME is a time variable and λ the rate of labor efficiency growth. Second, ΔGDPBV and ΔETB, which cannot be collected, are to be substituted by measurable variables. Generally, as a substitute for the variables we can write:

$$\Delta X_t = X_t - (1 - d_X)\, X_{t-1}$$

The subscript t is for time and d_X is a salvage rate. As the logarithmic approximation for this expression can be used:

$$\log\Delta X_t = \log d_X + \log X_{t-1} + (1/d_X)\, \Delta\log X_t$$

[15] With production function (4) there is a clear relationship between Total Factor Productivity TFP and labor efficiency ELEFFU: $TFP = ELEFFU^{\alpha}$. Thus we can treat both technology concepts here synonymously, which is done throughout the text in the following.

Third, to incorporate dynamics lagged investment is introduced in the investment function as an additional explanatory variable. This can be justified if, i.e., delivery of investment is distributed over time and it takes time to incorporate delivered capital into the production process. Finally, we have to check for structural breaks in our data set, which is supposed to having occurred around year 1995.

All these taken into consideration in (5) and (6) and after some rearrangements, following factor demand equations are obtained as a basis for calibration (the intercept is now again included and the time index t ignored throughout the following analysis):

5.7 $logIPV - logIPV_{-1} = c_7 + \beta/\delta\ (logGDPBV - logGDPBV_{-1}) - \beta\ [logIPV_{-1} - logGDPBV_{-1} - XTAU\ (log(WSSE/XTAU) - log(UCC/(1-XTAU)))+XTAU\ \lambda\ TIME] + \gamma\ DUMMY$

5.8 $logETB - logETB_{-1} = c_8 + (logGDPBV - logGDPBV_{-1}) - \delta\ [logETB_{-1} - logGDPBV_{-1} + (1-XTAU)\ (log(WSSE/ XTAU) - log(UCC/(1-XTAU))) + XTAU\ \lambda\ TIME] + \eta DUMMY$

The variable DUMMY has been introduced into both equations now additionally to take account for a possible structural break in the data. The equations (5.7) and (5.8) are very similar to error-correction models (ECM), with the error terms in square brackets, though they have not been formulated as ECM-models explicitly. One feature of the error-correction model is that the coefficients of the error terms have specific economic meanings: β in the investment function equals the adjustment lag in investment and δ in the employment equation is the depreciation rate of employment and output. Besides, our modeling technique allows for the separation of short-run dynamics from the long-run impacts of CSF interventions, the latter being of most interest of course for EU-policy.

An econometric estimation of all coefficients in the factor demand equations (8 parameters) with the limited available data (10 observations) is infeasible and altogether doomed to fail. Therefore, we have in a first step reduced the number of the parameters to be estimated by inserting their values obtained from other investigations for Hungary. The elasticity of output with respect to labor can be approximated by the labor share in national income, which tends to be close to two thirds in most OECD countries (see OECD 2000, 218). We set the coefficient α to this level, though statistical data for Hungary indicates a slightly lower value (see Hviding 1999). Besides, from calculations of capital stock data for Hungary (see Darvas and Simon 1999) an average depreciation rate, δ, of 0.10 can be derived, which is in line with international standards and also used by the OECD in its estimation of potential output growth for Hungary (see OECD 2000, 218 f.). XTAU and δ are substituted by these assumptions in equation (5.7) and the remainder of the coefficients is estimated by OLS yielding the following equations:

5.9 ETB = ETB(-1) * EXP(- 0.6462765982 + LOG(GDPBV / GDPBV(-1)) - 0.1 * (LOG(ETB(-1) / GDPBV(-1)) + (1 - XTAU) * LOG((WSSE / XTAU) / (UCC / (1 - XTAU))) + XTAU * LOG(ELEFFU)) + 0.01838048857 * (DUMMY_95_96 + DUMMY_99_02) - 0.0346201138 * DUMMY_92_94 - 0.01127018745 * DUMMY_93)

5.10 IPV = IPV(-1) * EXP(-0.4640446414 - 0.1313832514 * (LOG(IPV(-1) / GDPBV(-1)) - (1. / 0.1) * LOG(GDPBV / GDPBV(-1)) - XTAU * LOG((WSSE / XTAU) / (UCC / (1. - XTAU))) + XTAU * LOG(ELEFFU)) + 0.0565779131 * (DUMMY_94_96_98_99) - 0.03849758663 * DUMMY_95_01_02 - 0.02338901205 * DUMMY_97_98)

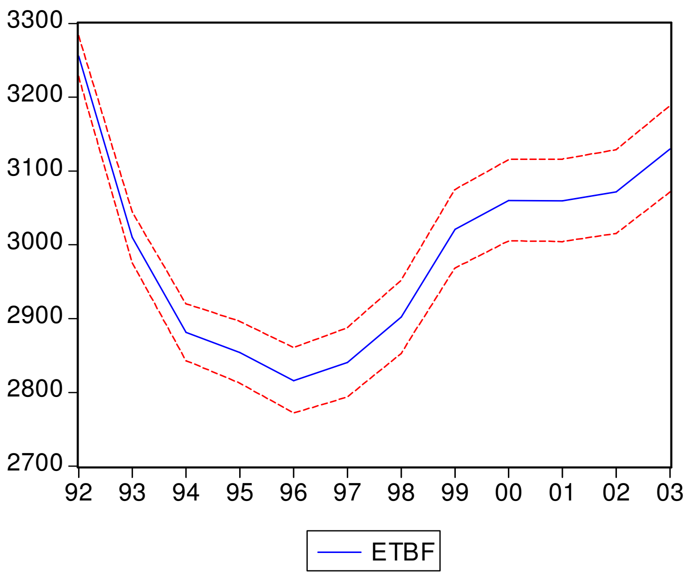
Interestingly, the growth rate of labor efficiency, λ, seems to be fairly high (2.2 percent). However, this value implies a growth rate for the Total Factor Productivity (TFP) of 1.49 ercent (XTAU*λ).[16] This value is in accordance with the values used in both the TFP as well as the SCGE sub-models.

Before using the model for multiplier analyses and simulation respective evaluation of CSF policies it should be tested for its capability to describe the empirical facts that have been used for its calibration. That a model is able to reproduce the historical data is a necessary (though

[16] Total Factor Productivity is given by: TFP = $ELEFFU^{\alpha} = e^{\alpha \cdot \lambda \, TIME}$. Thus, the growth rate of TFP is the growth rate of labor efficiency multiplied by the partial production elasticity of labor.

not sufficient) condition for it to be realistic. Besides, such a check on the model within sample properties may provide us with valuable information on the quality of our calibration process and point out where it has to be repeated. In the figures below plots of the forecasts with plus and minus two standard error bands are provided. These two standard error bands provide an approximate 95% forecast interval.

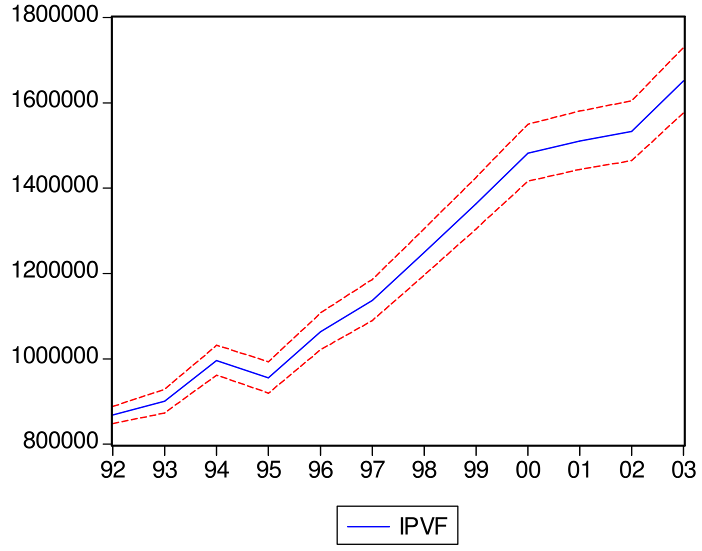
To examine the ability of the calibrated equations to provide forecasts of investment and employment demand we perform simulations which use the historical values of the exogenous variables in each equation and solve for the endogenous investment and employment variables. The resulting ex-post predictions for the variables are then compared to their historical values. The mean absolute percentage error (MAPE) of the simulated from the actual levels for the endogenous variables is then used as a measure for the forecasting ability of the model equations. According to a commonly applied rule of thumb in cases MAPE is less than 5 percent forecasting ability of the model is acceptable. Because on the right-hand side of the equations appear also the lagged endogenous variables as explanatory variables two types of simulations can be performed. If for the lagged endogenous variables the actual historical data are used, it is a question of a static simulation, and of a dynamic simulation when the values assigned to the lagged endogenous variables are the forecasts from previous periods. Figures 5.1 and 5.2 exhibit forecasted values and the respective MAPEs for the employment and investment equations. For both cases forecasting power is excepcionally good.



Forecast: ETBF
Actual: ETB
Forecast sample: 1992 2003
Included observations: 12

Root Mean Squared Error	9.795858
Mean Absolute Error	8.102311
Mean Abs. Percent Error	0.273212
Theil Inequality Coefficient	0.001636
Bias Proportion	0.016865
Variance Proportion	0.353946
Covariance Proportion	0.629189

Fig. 5.1: Forecast of employment (ETB)



Forecast: IPVF
Actual: IPV
Forecast sample: 1992 2003
Included observations: 12

Root Mean Squared Error	11497.23
Mean Absolute Error	10039.12
Mean Abs. Percent Error	0.796254
Theil Inequality Coefficient	0.004595
Bias Proportion	0.195689
Variance Proportion	0.131498
Covariance Proportion	0.672812

Fig. 5.2: Forecast of investment (IPV)

5.3 Output

The output equation for the business sector is, as the factor demand functions, also based on the theory of the firm and contains both demand side as well as supply side aspects. The decision of the firms about the level and location of production depends upon cost conditions and demand factors. In formulating the output equation we relied on the theoretical base of the OECD-INTERLINK model presented in Turner, Richardson and Rauffet (1996).

The demand factors affecting the capacity output are represented by the final domestic demand variable FDDV and net export (the difference between export and import XGSV-MGSV). FDDV captures the influence of national demand on output. It also serves to take into account the counteracting effects of wages on foreign direct investments: a high wage level might deter new plants from abroad because of high production costs but also attract them because of high demand potential. In addition, a high wage level can be viewed as an indicator for the availability of highly qualified labor and therefore may influence location decisions of firms abroad positively.

Following general form for the output equation the following summarizes our theoretical considerations:

(5.11) $GDPBV = f_9\,(WSSE, ELEFFU, PGDPB, FDDV, XGSV, MGSV)$

In addition to the previously discussed variables we introduced WSSE to represent labor costs. This is in accordance with the suggested formulation of the production cost effect in the OECD-INTERLINK model. The price index PGDPB was also included which is as a determinant of output self-explanatory. To estimate parameter values for each variable in (5.11) with OLS is, however, due to insufficient data (12 observations) an impossible task. In addition it turned out that some data prior to 1994 were too bad and couldn't be used at all for estimation of the output equation. Therefore, the parameters to be estimated had to be reduced. To accomplish that without giving up too much of the theoretical content of our approach, we came up with the following general form of the output equation:

(5.12) $GDPV = f_9(WSSE/PGDP/ELEFFU, (FDDV+XGSV-MGSV)$

Where the first variable is the efficiency real wage a major determinant of production costs while the second term captures aggregate (domestic and foreign) demand.

The following is the calibrated equation:

(5.13) GDPBV = EXP(7.153939065 - XTAU * LOG(WSSE / PGDPB / ELEFFU) + 0.8096641143 * LOG(FDDV + XGSV - MGSV) + 0.02891037751 * DUMMY_98_00_01)

As can be seen from Figure 5.3, also the forecasting ability of the output equation appears to be quite satisfactory, considering the short time series available for calibration.

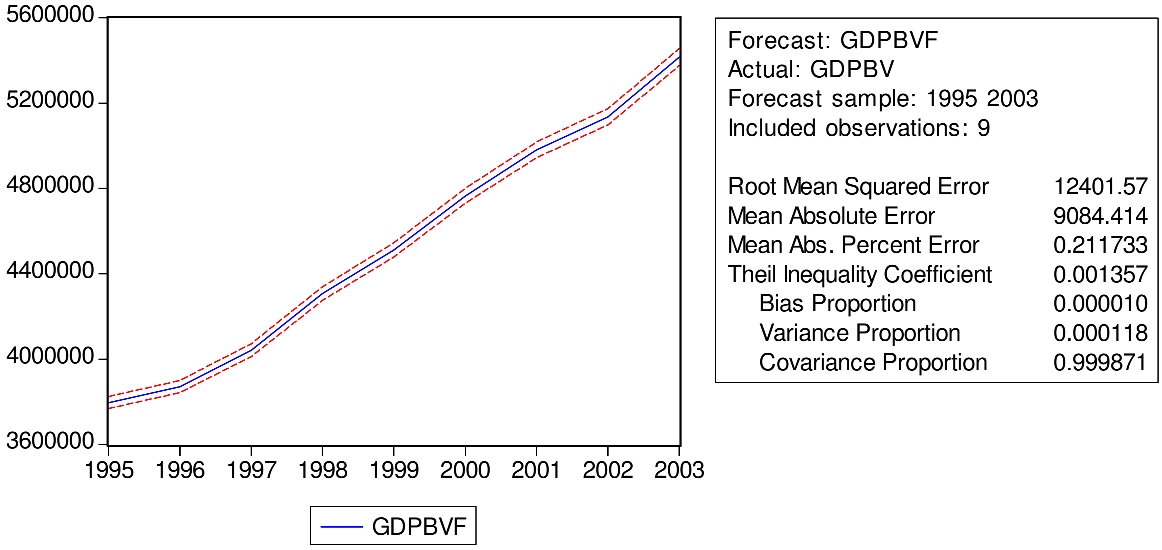


Fig. 5.3: Forecast of output (GDPBV)

5.4 Wages and prices

The formulation of the wage equation relies on the theoretical base applied in the OECD-INTERLINK model. The compensation rate of the business sector WSSE, defined as the total annual wages per employee in this sector, is assumed to be determined in a bargaining framework. According to the theory of bargaining, there are three factors at least, which play a dominant role in the wage setting process. The first factor, which affects nominal wages, is the price level. This is so, because both firms and workers do not care so much about nominal wages, but about real wages. Workers want to secure their living standard and will therefore try to receive a rise in wages at the inflation rate at least because this leaves their real wages unchanged. In the same way, employers will agree to pay higher wages, if the price of their products increases by the same amount. Therefore the consumption price index PCP is the first determinant of our wage equation for the business sector.

The second explanatory variable affecting wages is the unemployment rate UNR, which represents the bargaining power the workers have or the prevailing labor-market conditions. At low unemployment rates, workers are in a stronger bargaining position, thereby exerting higher pressure on nominal wages. In short, lower unemployment rates will lead to higher wages. Finally, evidence suggests that wages also depend on the trend of productivity. If productivity increases, workers and employers will reflect this in the bargained wage according to their relative bargaining power. Thus, as third explanatory variable the trend of labor productivity in the business sector, PROD, is included in the wage equation, which now becomes:

(5.14) $$\log WSSE = c_1 + c_2 \log PCP + \log PROD + c_3\, UNR_{-1}$$

The estimation results obtained with data for the period 1992-2003 are as follows:

(5.15) $$WSSE = EXP(6.79515674 + XTAU * LOG(ELEFFU) + LOG(PCP) - 0.09506299279 * (DUMMY\_99\_00))$$

In the estimation we proxied labor productivity by Total Factor Productivity. As was derived earlier $ELEFFU^{XTAU}$ is TFP. The message of the estimated equation is that in the long run TFP growth rate determines wage growth. The sensitivity of wages to the unemployment rate, the Phillips-curve effect, is very low, indicating only a minor role of labor market conditions in nominal wage bargaining. A relative low effect of the unemployment rate on wages is also obtained in other studies, e.g., by Cserháti and Varga (2000) for Hungary, Christodoulakis and Kalyvitis (1998) for Greece, and "imposed" by Bradley, Morgenroth and Untiedt (2001) in their wage equation of the manufacturing sector for East Germany on the basis of comparisons with Ireland. The unity coefficient of the consumer price index is completely in accordance with theoretical considerations.

Historical data is explained quite satisfactorily by the calibrated wage equation, as can be seen from Figure 5.4.

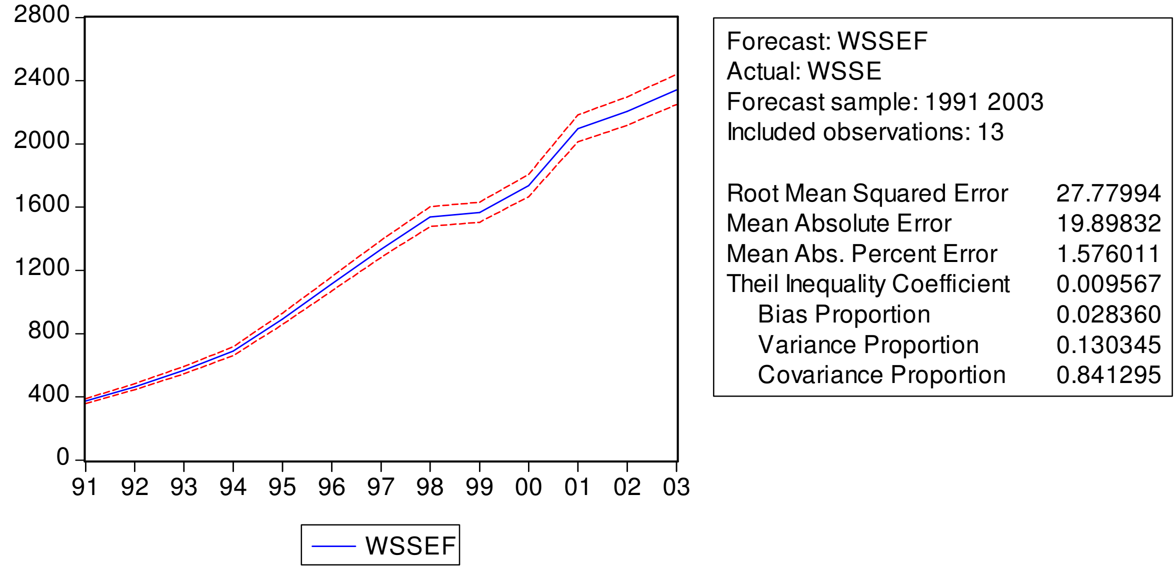


Fig. 5.4: Forecast of wages (WSSE)

The derivation of an equation for the pricing behavior of the business sector draws on the corresponding modeling in Turner, Richardson, Rauffet (1996). The output price PGDPB depends on production costs and costs depend on the nature of the production function. When deriving the factor demand equations in section 5.2 we assumed, that firms produce output-using capital and labor as factor inputs according to the production function in (5.4). This function takes also into account labor efficiency, ELEFFU, (or total factor productivity TFP) as a factor of production, explicitly. Theory of the firms tells us, that marginal cost of production is equal to unit capital-labor costs CKL, as derived in section 5.3. And if there were perfect competition, this would be equal to the price of output, PGDPB. But because the goods markets are not competitive, a higher price than unit capital-labor costs is charged. To capture this fact it is assumed that the price for business output is set according to the equation:

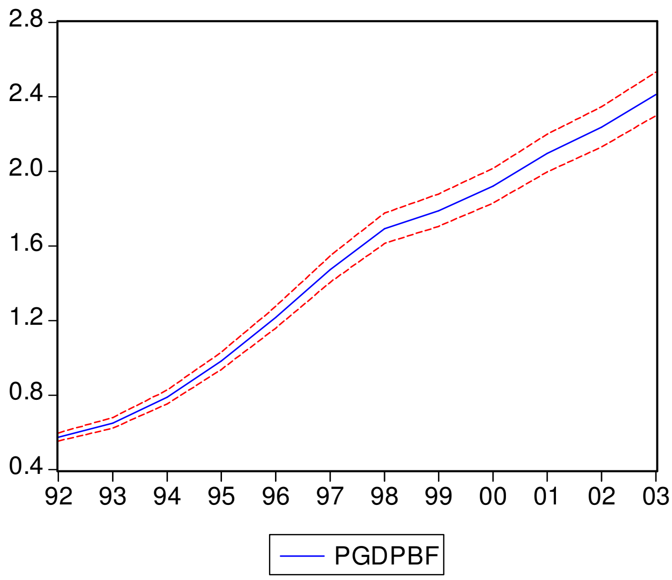
(5.16) $$\log PGDPB = c_1 + c_2 \log CKL + c_3 \log PGDPB_{-1}$$

where the parameter c_2 captures the strength of the effect of unit capital-labor costs on prices, which depends on the extent that the goods markets are competitive and the firms have market power. In (5.12), by the one period lagged endogenous variable sluggish adjustment of the price level to its equilibrium value shall be taken into account.

This approach for price determination is in full accordance with supply side theory followed so far when deriving the factor demands and output equation. In contrast to other models also capital costs and not only wages are considered as determinant of prices. In addition, ELEFFU or total factor productivity is included and in that way a further channel created, through which CSF measures can affect directly the supply side: an increase in ELEFFU due to investments in human resources, e.g., decreases production costs (see equation (5.12)), dampens price increases and improves competition.

A major advantage of our approach is that, in comparison to the included variables, only a smaller number of coefficients have to be calibrated with the limited data. The estimation results are as follows:

$$\begin{aligned}(5.17)\qquad & \mathrm{PGDPB} = \mathrm{EXP}(-2.184324816 + 0.3752619755 * \mathrm{LOG}(\mathrm{CKL}) + \\ & (1-0.3752619755)*\mathrm{LOG}(\mathrm{PGDPB}(-1))+0.05440570567* \\ & \mathrm{DUMMY\_96\_97} - 0.05222860349 * \mathrm{DUMMY\_99})\end{aligned}$$



Forecast: PGDPBF
Actual: PGDPB
Forecast sample: 1992 2003
Included observations: 12

Root Mean Squared Error	0.022633
Mean Absolute Error	0.019305
Mean Abs. Percent Error	1.304364
Theil Inequality Coefficient	0.007044
Bias Proportion	0.003496
Variance Proportion	0.027274
Covariance Proportion	0.969230

Fig. 5.5: Forecast of prices (PGDPB)

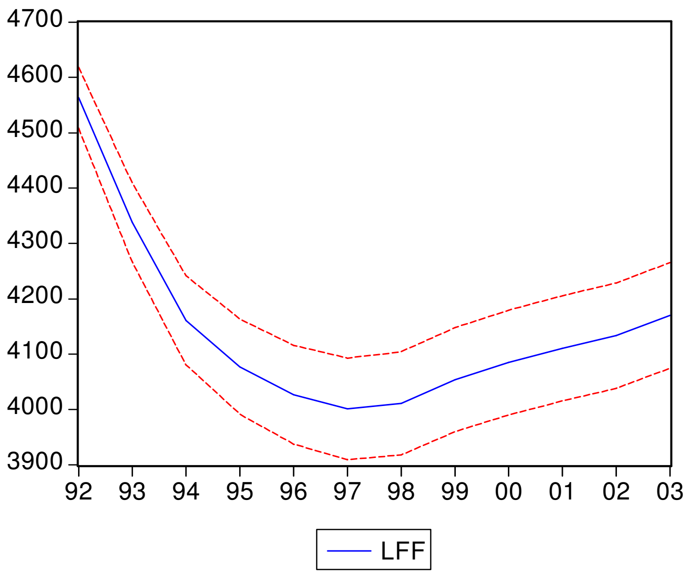
The deflators for private consumption, PCP and private investment, PIT were modeled as the weighted average of the price for business output and import prices in the long run. See for the calibration results and the modeling of the remaining deflators the equation system listing in the appendix.

5.5 Labor supply

Labor force is estimated according to the following equation:

(5.18) $$LF = POPT * (0.1254955234 + 0.8184106563 * (LF(-1) / POPT(-1)) + 0.1884826701 * LOG(ETB / ETB(-1)) - 0.00263766064 * UNR(-1))$$

As can be seen from Figure 5.6 the estimated LF equation, delivers an excellent forecast of the labor force with relative residuals of less than a half percent in each year of the observation period.



Forecast: LFF	
Actual: LF	
Forecast sample: 1992 2003	
Included observations: 12	
Root Mean Squared Error	20.29329
Mean Absolute Error	16.99619
Mean Abs. Percent Error	0.407575
Theil Inequality Coefficient	0.002446
Bias Proportion	0.028669
Variance Proportion	0.007881
Covariance Proportion	0.963450

Fig. 5.6: Forecast of the labor force (LF)

5.6 Final demand

The derivation of a function for private consumption is based on a relationship between consumption CPV and household real disposable income YDRH that is one of proportionality:

(5.19) $$CPV = \beta\ YDRH$$

In this relationship the elasticity of consumption with respect to income is unity and β the average propensity to consume. The latter might not be a constant and consumption is likely to respond less than one for one to fluctuations in current income. E.g., if the economy experiences a rapid increase in income, private consumption is unlikely to increase by as much. Hence β will fall as the growth rate in income rises. This relationship has, in fact, been observed empirically: countries with higher economic growth rates do tend to have lower average propensity to consume (Thomas 1997, 386). Therefore, one determinant of β is the growth rate of YDRH, where a negative sign for its effect on the propensity to consume is expected.

Other decisive determinants suggested in recent research work are wealth and interest rates (see Mankiw 2003, Chapter 16). Because of lack of data, wealth cannot be taken into account. From interest rates, which can be represented by the variable IRL, two counteracting effects on the propensity to consume are expected (Franz, Göggelmann, Winker 1998): a negative substitution effect, because high interest rates favor consumption in the future in relation to present consumption, and a positive income effect, resulting from the interest returns from wealth.

These theoretical considerations and after some experimentations with data and mathematical forms the equation for private consumption was formulated as follows:

(5.20) $$\log CPV = c_1 + c_2 \log YDRH + c_3 \log(YDRH/YDRH_{-1}) + c_4\, IRL + c_5\, DUMMY94 + c_6 \log(CPV_{-1}/YDRH_{-1}))$$

In addition to the discussed variables the average propensity to consume of the pre- period has been included, to allow for lagged adjustment in consumption behavior, and a dummy variable as well to take into account a structural break in consumption expenditure observed in 1994.

The results for this calibration are shown in equation 5.22. All coefficients have the theoretical expected signs, where the parameter value connected with the interest rate indicates that the negative substitution effect on consumption outweighs the positive income effect. Not surprisingly and in accordance with other studies the overall effect is however rather low.

(5.21) CPV = YDRH * EXP(0.067187 + 0.745648 * LOG(CPV(-1) / YDRH(-1)) - 0.588445 * LOG(YDRH / YDRH(-1)) - 0.005051 * IRL + 0.02838 * DUMMY94)

Figure 5.7 demonstrates the nearly perfect performance of the calibrated consumption function against historical data.

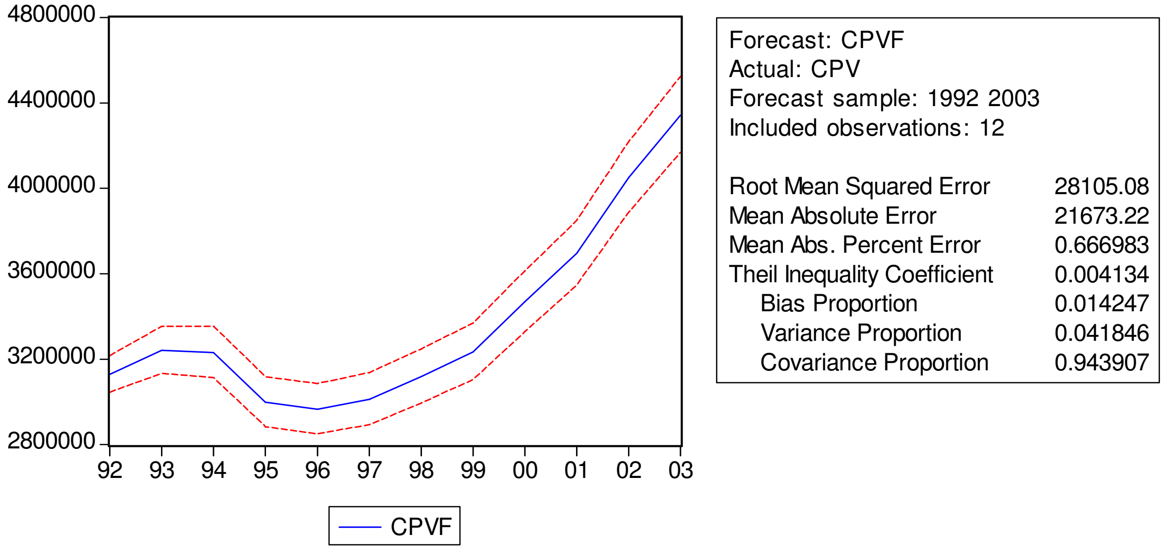


Fig. 5.7: Forecast of private final consumption (CPV)

With the consumption function about 50 percent of total final demand is explained. Another 21 percent fall to business investment IPV, which was modeled jointly with the employment function in section 5.2. Government final consumption and investment are treated as exogenous in our model or follow developments in the business sector or the total economy. What remains to be explained from final demand are therefore exports and imports. They are not modeled separately here but their difference instead, the net exports of goods and services FBGSV, as follows:

(5.22) FBGSV = GDPV – TDDV

GDPV denotes real gross domestic product and TDDV contains all components of real final domestic expenditure[17]. A similar equation as (5.22) is formulated for net exports in nominal terms.

[17] See the equation system in the appendix for further information.

5.7 Income distribution and government

In this block of the model the redistribution of factor incomes through transfers, taxes and the social security system between the private and government sectors is explained. We drew in the modeling of this block mainly on the OECD-INTERLINK models.

Only the current transfers received by households, TRRH, is modeled econometrically as follows:

$$(5.23) \qquad TRRH - TRRH_{-1} = 0.456\ (WSSE \cdot UN)$$

where WSSE is the compensation per employee in the business sector and UN total employment. Linking them by means of „rates“ to their appropriate base endogenizes other variables. E.g., direct taxes on households, TYH, and on business, TYB, are explained by:

$$(5.24) \qquad TYH = (TYH_{-1}/YRH_{-1}) \cdot YRH$$

and

$$(5.25) \qquad TYB = (TYB_{-1}/PROF_{-1}) \cdot PROF$$

YRH and PROF denote current receipts of household's respective business profits. In a similar way social security payments are modeled, e.g. the employees and self-employed contributions to social security as:

$$(5.26) \qquad TRPESH = (TRPESH_{-1}/(WAGE_{-1} - WAGEG_{-1} + YSE_{-1})) \cdot (WAGE - WAGEG + YSE)$$

where WAGE and WAGEG denote wages of the total economy and government sector, respectively, and YSE, the self-employment income received by households, is itself indexed to the compensation rate of the business sector, WSSE, and the self-employed, ES, by way of

(5.27) $$YSE = (YSE_{-1}/(ES_{-1} \cdot WSSE_{-1}))\ (ES \cdot WSSE)$$

We hold on this kind of modeling later when performing forecasts and simulations with the model for future periods. By doing so the respective "rates" are set to their values of the last historical year, 2001, and held fixed over the forecasting period.

5.8 Modelling sectoral values

To simulate investment, employment and output at the level of the three business sectors (agriculture, industry, services) we followed a combined top-down-bottom-up approach. This means that annual change of aggregate employment and investment is generated at the macro model then the sectoral values are calculated in the SCGE sub-model for regions. Aggretion from the regional to the macro level provides the macro sectoral values of investment, labor and output. For sectoral wages (that are not calculated in the SCGE model and are available at the macro level.) we followed a different approach. A top-down approach was taken as in the sectoral wages equations values are driven by the aggregate wage.

5.9 CSF Policy variables[18]

On the *demand side* CSF expenditure going on investment in basic infrastructure and expenditures not expected to exert supply side effects at least in the medium term (such as environmental investments) enter the model through an additive term BIV in the equation that describes government fixed capital formation:

(5.28) $$IGV = IG / PIT + BIV$$

[18] This section updates Schalk and Varga (2004) 7.2.2.

Expenditure on education/training and research and development, HUMRES are treated as an income transfer to private households, exerting a demand shock through an additive factor in the equation for household disposable income:

(5.29) YDH = YRH – TYH - TRPH + (HUMRES)

Regarding the aids for productive structures or investments, PEV, it is assumed that they are granted as an investment tax credit whose rate G1 is expressed as percentage of private investment, IPV:

(5.30) G1 = PEV/IPV

The investment tax credit reduces the user costs of capital, UCC, by G1 percent:

(5.40) UCC = (UCC_ELEFFU / PIT_ELEFFU) * PIT * (1 - G1)

where PIT is deflator of gross total fixed capital formation. The user cost of capital variable is a main determinant of business investment demand. Thus, the supports for the productive environment are introduced into the model via the investment function: UCC is reduced by the financial supports, thus increasing investment demand in the business sector and output from the demand side.

But the user cost of capital enters also several other equations on the supply side of the model. Besides wages it enters the labor demand function, thus affecting employment in the business sector. In addition, it is amalgamated with wages into the unit capital-labor cost variable (CKL), one of the key variables in the model, which has important effects on the output supply in the business sector and enters also directly and indirectly all price equations of the model. Therefore it is difficult if not impossible to study with the model the supply side effects of the user costs of capital and thus of the CSF supports for productive structures separately from their demand side effects. We will come back to this point again when the scenario results are presented.

The demand side impacts of a change in the policy variables can be quite different, depending on the multipliers associated with the payments of the various CSF investment programs. Besides, it must be taken into account that these multipliers are dynamic insofar as their values change in time.

In contrast to financial supports going on investment in productive structures the *supply side* effects of all other CSF interventions are introduced into the model by way of a function explaining the Total Factor Productivity. This effect is treated in more details in the following chapter.

6. Integrating regional and macro levels in the complex model: Structure, mechanisms of CSF impacts and model properties

6.1 Model structure

The complex macro-regional model is designed for development policy analysis and not for forecasting. It is an extension of a macro model originally developed in Germany (Schalk and Untiedt 2000). The first step to make this model suitable for impact analysis of TFP-related CSF instruments was done while EcoRET was developed (Schalk and Varga 2004). In EcoRET these effects were modeled in a static geographic setting. This means that with EcoRET short run effects of CSF interventions on regional and macro TFP are estimated and then these are channeled to a macroeconomic framework. With the current extension (called GMR – Geographic Macro and Regional model) it is possible to estimate the long run dynamic geographic effects by way of integrating an SCGE model, RAEM-Light (Koike and Thissen 2005) into the framework. By dynamic effects we mean following the changes in the geographic structure of the economy initialized by CSF interventions. As such, migration of labor and capital is incorporated in the model. The previous sections outlined the sub-models in details. In this section the model structure is explained. To do this first the main sub-model characteristics are underlined again and then the complex system is introduced. Only CSF effects related to the geography of TFP are described in this chapter. Other effects such as the impact of investment support and demand side influences of interventions are already described in previous sections.

6.1.1 Main sub-model characteristics

A. The TFP sub-model

The TFP equation (equation 3.1) is placed to the center of this sub-model. This equation estimates the effects of geographically differently located knowledge sources (local, national, international) as well as the impact of specific CSF instruments (human capital, infrastructure) on TFP growth rate. The equation is estimated on a space-time data set. It is used to generate *static* agglomeration effects (direct short-run effects on TFP levels in each region) as a result of CSF interventions. Macro level static and dynamic TFP changes are also calculated in the TFP sub-model.

B. The SCGE sub-model

The reason this sub-model is integrated into the framework of GMR is to make it suitable for studying the longer run spatial effects of the schocks CSF intervention exerts on the economy. This model is calibrated in a way that without interventions it represents a full spatial equilibrium of the economy (both regionally and interregionally). This basically means that no migration of labor and capital is assumed as there are no differences across regions in utility levels. CSF-related schoks interrupt this state of equilibrium and the model describes the gradual process towards a new full spatial equilibrium. As such this model predicts the likely *dynamic* agglomeration effects. Compared to static effects (estimated by way of the TFP equation) dynamic spatial effects incorporate changes in the spatial structure of the economy resulting from CSF-interventions followed by labor and capital migration.

Changes in the geographic structure are determined by the relative weights of centrifugal (changes in local knowledge measured by TFP) and centripetal (transport cost, congestion) forces. Agglomeration plays its role right in the beginning of the process as the change in TFP in any region depends both on the size of support and on employment (which is a crude measure of agglomeration externalities in technological change) already in the region (static agglomeration effects). Agglomeration forces are also present in later stages of the dynamic process. This happens not only because of the fact that interregional differences in TFP determine the intensity of migration but also because the intensity of migration further reinforces these differences. The strength of this cumulative process depends first on the propensity of labor to migrate and second on the importance of negative agglomeration externalities.

As a result the SCGE sub-model calculates dynamic regional TFP changes and values of output, employment, investment and wages at the level of counties. It might seem paradoxical but despite it describes the dynamism of the spatial structure this sub-model does not incorporate all the forces necessary to build a full spatio-temporal system. Crucial elements of this dynamism such as changes in technology, employment and capital are exogenous in the system. These effects are formulated in the MACRO sub-model.

C. The MACRO sub-model

Based on dynamic TFP effects (calculated by the TFP and the SCGE sub-models) the MACRO sub-model estimates the likely macroeconomic effects on several variables such as the level and growth of output, investment, employment, wages, unemployment, inflation and so one. The MACRO sub-model provides a complete picture of the macro economy with supply, demand and income distribution blocks included. This model is estimated as an a-spatial system. As such it incorporates agglomeration forces in estimation as they are present in macro data but studying the effects of their changes is out of its possibilities. The results bear spatial features only because of its extension with the TFP and SCGE sub-models. The MACRO baseline describes the economy assuming no CSF-interventions occur. As such it is built on the proposition that the spatial structure of the economy does not change compared to the period of estimation. With policy simulations the effects of TFP-related (infrastructure and human capital) and not directly TFP-related (investment support) instruments are estimated.

6.1.2 The structure of the complex model

Fig. 6.1 describes the way the different sub-models are interrelated in the complex system. Following this figure the current section explains the model structure in details.

Step 1: the monetary value of TFP-related CSF instruments (human capital support, infrastructure investments) enter the TFP equation (eqution 3.1) to calculate static changes in TFP growth rates for each county and for each year.

Step 2: Equations 4.1 and 4.2 channel the static changes in TFP growth rate into the SCGE model to estimate long run dynamic spatial effects. Determined by positive agglomeration effects (regional changes in TFP) and negative agglomeration forces (transport costs, congestion in the housing market) the SCGE sub-model calculates the values of TFP, output, investment, employment and wages for each county for the whole period of intervention.

Step 3: Dynamic TFP levels for each year enter the TFP sub-model to calculate national TFP growth rate changes. The way to calculate these first include calculation of national TFP levels as weighted averages of regional TFP levels (where county employment is used for

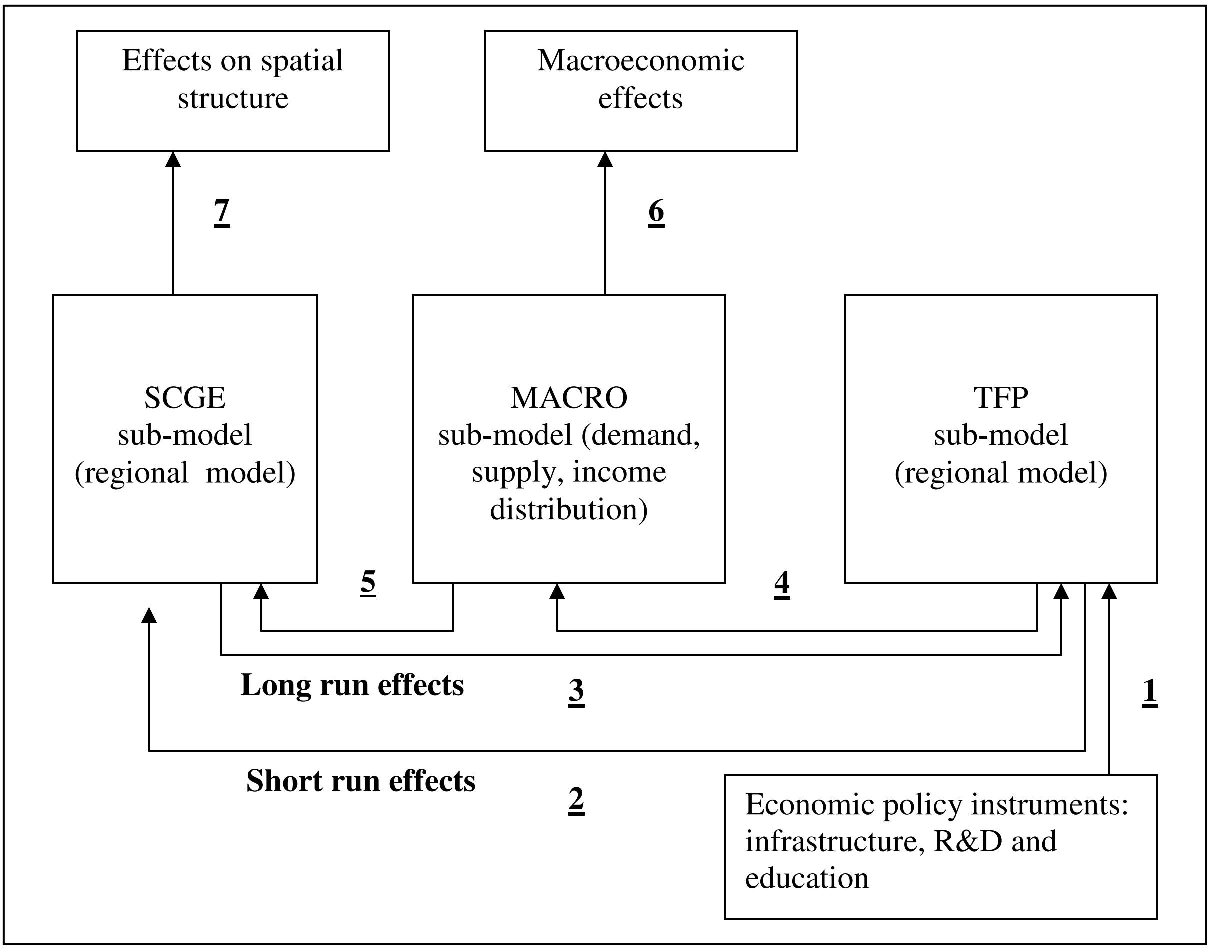


Fig 6.1: Regional and national level short run and long run effects of TFP changes induced by development policy scenarios

weighting to incorporate agglomeration effects). As referred to earlier this procedure ends up with a precise estimate of national TFP. Then national TFP growth changes are calculetd from TFP levels and these values channel into the macro model with the help of the following equation:

6.1 $\quad CSFTFP = ELEFFU^{\alpha}\, e^{DNTFPGR} = e^{\alpha \cdot \lambda\, TIME} e^{DNTFPGR}$

where $\alpha \cdot \lambda$ is the national growth rate of TFP as estimated by the macro-model and DNTFPGR is its *change* resulting from CSF interventions. Thus, CSFTFP is the *level* of Total Factor Productivity at each point in time due to CSF policies and other factors. 6.1 is the key equation in linking the dynamic regional models (TFP and SCGE sub-models) of technological change to the macroeconomic sub-model.

Step 4: The simulated new national TFP value in equation 6.1 channels productivity change induced by CSF interventions into the macroeconometric sub-model as the variable TFP feeds directly or indirectly into several equations of the system, as depicted in the Appendix.

Step 5: As a result of CSF interventions channeled by dynamic TFP changes, demand side effects and investment support (the latters are not detailed here) employment and investment changes are estimated in the macro model. As underlined earlier the SCGE model takes changes in technology, labor and capital exogenous. For consistency of the system changes in employment and investment generated in the MACRO sub-model enter the SCGE sub-model to calculate the final spatial distribution of labor, investment, wages and output. This was necessary as the SCGE model part does not provide an endogenous approach for employment and investment growth.

Steps 6 and 7: The complex model system provides the effects of CSF interventions in the form of percentage differences to the baseline (i.e., the state of affairs without policy impacts) both at the regional level (output, investment, employment, wages) and at the macro level (output, employment, investment, wages, unemployment, inflation rate, productivity etc.).

6.2 The mechanisms of the impacts of geographically modeled CSF interventions

A. Infrastructure, R&D and education support

A.1 Regional effects

Resulting from development policy interventions changes in regional TFP affect regional level equilibrium values (output, employment, investment etc.) both in the short run (in the same year) as well as in the longer run (during the coming years). As such one time changes could generate a cumulative long run process. This process is detailed more concretely in the following steps:

i. Assuming that the intervention occurs in any i^{th} region (where i can of course be more than one region), the change in A'^{m}_{i} (i.e., regional TFP level in the m^{th} sector) generates the following effects in the *short run*: f.o.b price of the good decreases that induces a decrease in the demand for both L and K (assuming y unchanged). At the same time the effect of price change on interregional trade ($z_{i,j}$)is positive as well as the impact on output (y_i^m) resulting in an increase in the demand for K and L (output effect) [19]. Additionally, the decline in p_i^m inducing an increase in regional demand (x_i^m, h_i) results in higher utility levels at location i.

ii. Interregional restructuring in utility levels is followed by labor migration in the next period (next year). There is also an effect on the interregional re-allocation of capital. Labor movement results in changes in regional productivity in the longer run (dynamic agglomeration effects).

iii. Changes of TFP levels induce a longer run cumulative causation process invoking changes in the geographical structure of the whole economy.

A.2 Macroeconomic effects

Following the process described under i and ii TFP growth rate changes are calculated for each time period. These values are channeled into the macro sub-model according to equation 6.1.

B. Regional and macroeconomic mechanisms of changing transportation costs (resulting from highway and railway investments)

Infrastructure support described under 6.1 decreases production costs through increasing TFP. This impact works via the TFP sub-model. However, infrastructure investment support has an effect on interregional trade of outputs and this effect is modeled by the SCGE sub-model. Consequently the modeling system describes both the input and the output side effects of infrastructure development. The output side effect is modeled by the transportation markup rate parameter $t_{i,j}$. The mechanisms work as follows in the SCGE sub-model.

[19] Note that the mechanism of the impact of a change in TFP on output, K and L follows the same logic both at the macro level (Fig. 2.2) and at the regional level. In both models the impact on K and L depends on the relative strengths of the output and substitution effects.

B.1 Regional effects

Via decreasing prices a decline in $t_{i,j}$ increases interregional trade between regions i and j and also the demand for K and L. The increase in demand for L is followed by increasing utilities in the given region. Changing labor demand paired with a relative restructuring in interregional utility differences induces labor migration causing changes in regional equilibrium values (production, employment etc) as well as regional TFP levels (agglomeration effect).

B.2. Macroeconomic effects

Regional changes in TFP growth rates are calculated for each time period and these changes feed into the macroeconomic sub-model by equation 6.1.

6.3 Model properties

The structure of the complex model was outlined in the previous section. Several questions can be raised as to the properties of the complex model. We classify these issues into two sets: the first one is related to the consistency of the complex model whereas the second one is to sensitivity of model results to certain exogenous changes[20].

6.3.1 Model consistency

Despite that the two main components of the complex model (EcoRET and RAEM-Light) are developed separately from each other, several features (such as the application of a Cobb-Douglas production function, cost minimization by firms, a strong supply side orientation, modeling technology by way of TFP, the realization of the importance of agglomeration externalities) suggests that reaching internal consinstency in the complex model is a realistic possibility. The clear division of labor between the three sub-models outlined in the previous sections also suggests a consistent structure. However there are some important issues that are

[20] Sensitivity analyses on demand and supply side schocks in the macromodel reported in Schalk and Varga (2004) are not repeated here.

not automatically solved by model assumptions and need original solutions. These are related to those parts of the model where the main elements are being connected together. As such, the following areas emerge:

1. Channeling TFP growth rate changes into the SCGE sub-model;
2. Harmonizing national level employment and investment changes between the MACRO and the SCGE sub-models;
3. Harmonizing changes of output between the MACRO and the SCGE sub-models.

1. With respect to the first issue it is assumed that TFP grows exogenously both in the SCGE as well as in the MACRO sub-models by the average rate of growth experienced from the second half of the 1990's and this growth rate is altered by CSF interventions. This is a suitable assumption as the interest of the modeling work is not in forecasting but in impact analysis. Change of TFP generated in equation 3.1 enters the SCGE sub-model as a schock via equation 4.2. This increases TFP for each individual region according to the extent of intervention and then channels into the MACRO sub-model by way of equation 6.1.

2. For the second issue to be resolved we ended up with the solution that the SCGE model is being run two times during each simulation. In the first time it generates dynamic TFP levels for each region and after estimating national level changes in the TFP sub-model the effects on macro variables are calculated in the MACRO block (steps 3 and 4 in Fig 3.1). However, since aggregate changes in employment and investment are not explained in the SCGE sub-model these should come from outside of it. To ensure internal consistency of the model it is decided to apply changes in the two variables in SCGE as they are estimated in the MACRO sub-model. It caused some technical problems to resolve, however at the end it appeared to be a fully viable solution. As a result, after the second run of the SCGE sub-model (step 5 in Fig 3.1) there is a full consistency between the MACRO and SCGE model parts with respect to employment and investment changes. These changes resulted from changes in TFP (generated in the TFP and SCGE sub-models) and being related to several other variables in the MACRO sub-model on the one hand whereas spatial distribution of the change in employment and investment is calculated in the SCGE sub-model on the other.

Even the treatment of labor market in the the full neoclassical regional model and the macro model (that incorporates Keynesian demand side elements as well) do not show inconsistencies anymore in the complex model. The function of the SCGE model is to calculate the spatial distribution of employment that is estimated in the MACRO. This does not mean that full employment is assumed in the regional model. Its function is to provide the geographic counterpart of any levels of aggregate employment no matter how high the rate of unemployment in the economy is.

Despite that the linkages among TFP-SCGE-MACRO-SCGE represent a logical construct for employment and investment one issue still remained that could potentially harm internal consistency in this respect. This is related to the fact that TFP level is partly determined by agglomeration (Equation 2-b in Appendix 3). Is it not a realistic possibility that the resulting change in employment increases aggregate TFP levels significantly in the SCGE-TFP sub-models after running SCGE for the second time? In other words: should not we run the MACRO model again after the second run of SCGE? This way we would introduce a potentially long iterative process among TFP-SCGE-MACRO that was not expected originally.

It has been emphasized earlier that the SCGE sub-model is a static construction and dynamisms in employment and investment are brought into the system from the MACRO sub-model. The model has a "short memory" meaning that in any simulation during the first run of the SCGE model changes in employment and investment from one year to the other are the ones calculated earlier in the simulation that was run last time before. In the second run of the SCGE sub-model these changes are corrected by the respective values from the MACRO sub-model. However in extreme situations this technique might be the source of incorrect results. This is illustrated below.

In order to learn the properties of the complex model with respect to the effect of employment change on TFP growth rate we run several simulations and calculated elasticities for different geographical distributions of CSF instruments[21]. These computations are summarized in the following matrix.

[21] The same amount of CSF expenditures were used in the simulations as presented in the next chapter. Aggregate values as well as their distribution between infrastructure and human resources support are taken as fixed and only geographic distributions are changed.

	EQ	**BP conc**	NFH	Bp 25%	Bp 10%	Bp 15%
EQ	0,00	**18,55**	-0,09	0,38	0,01	0,07
BP conc	**-7,67**	**0,00**	**-7,71**	**-7,51**	**-7,66**	**-7,64**
NFH	0,09	**18,77**	0,00	0,48	0,10	0,17
Bp 25%	-0,37	**17,65**	-0,46	0,00	-0,37	-0,30
Bp 10%	-0,01	**18,53**	-0,10	0,38	0,00	0,06
Bp 15%	-0,07	**18,38**	-0,16	0,31	-0,06	0,00

EQ stands for equal spatial distribution of funds, NFH is the structure suggested by the National Development Office (more details are given in the next chapter in this respect), BP conc is the scenario when all the expenditures are concentrated in Budapest (a not realistic, but analytically interesting situation), Bp 10%, 15% and 25% are the respective shares spent in Budapest whereas the rest of the funds are equally distributed across the 19 remaining counties.

The matrix should be read from the first column. To have an example: the elasticity of 18.55 means that a one percent change in employment at the national level (generated by the MACRO sub-model) results in an 18.55 percent increase in national level TFP if a scenario of equal distribution of funds across regions is followed by Budapest concentration. It is clear from the matrix that as spatial concentration of funds increases the effect of employment change on TFP level increases as well. However this effect becomes strong only in the extreme scenario when Budapest gets all the CSF support. Even for the case of a 25 percent Budapest support (which does not seem to be realistic either) the elasticity value remains significantly below 1.

The message of the above simulations is clear. The TFP effect of employment change is severe only if concentration patterns change drastically: from even distribution to Budapest concentration or to a 25 percent concentration in the capital. In realistic analyses changes in national level employment does not change the spatial distribution of labor so drastically considering the relatively low level of migration across counties. Even a large increase in employment does not change the spatial pattern of labor drastically because of the relative stickiness of labor in space. Additionally, employment effects of CSF interventions are not strong as will be shown in the next chapter. Consequently we should not expect such significant changes in TFP at the national level that require the calculation of new results for the macro variables.

3. The remaining issue to resolve is the consistency of output estimates between the SCGE and MACRO model parts. Given that both sub-models employ a Cobb-Douglas production function and also both of them are built on the principle of cost minimization together with the facts that TFP, investment and employment grow at the same aggregate rate in each model parts consistency in this respect seems to be a likely feature. However, for a more precise knowledge of model properties we get into this issue in much more details.

Tab. 6.1: Comparison of CSF effects on GDP: MACRO and SCGE model results (in 1995 HUF)

Year	GDP		GDP Predicted: MACRO		GDP Predicted: SCGE		MACRO GDP in SCGE Units	
	MACRO	SCGE	Value	% Predicted	Value	% Predicted	Value	% of SCGE GDP
2008	9 722 645	15 652 027	9 258 690	95	15 467 422	99	16 242 498	104
2009	10 141 090	16 939 266	9 727 182	96	16 176 763	95	16 865 112	100
2010	10 558 940	18 374 617	10 145 129	96	17 406 437	95	18 116 431	99
2011	10 966 070	19 753 408	10 562 274	96	18 760 297	95	19 477 502	99
2012	11 360 030	21 149 205	10 968 509	97	20 035 492	95	20 750 659	98
2013	11 750 510	22 623 236	11 361 576	97	21 328 036	94	22 058 146	97
Mean				96		95		99

Note: The table follows the structure of CSF expenditures presented in details in chapter 7 in this report.

The main difficulty in comparing SCGE and MACRO results for output is that the two sub-models measure output (and also employment and investment) in different units.[22] The first two columns of Tab. 6.1 list estimated national level output values (resulted from the scenario that is detailed in the next chapter) at MACRO and SCGE. Because of different units used the two columns are incomparable. However to relate the two to each other we calculated predicted MACRO and SCGE values of output using the vintage capital production function originally applied only in the MACRO sub-model. The same change in labor and capital at the aggregate level, combined with the same level of TFP for both models resulted in two predictions for changes in GDP at MACRO and SCGE. By adding these changes to previous year GDP the new levels of output are calculated.

[22] The reason for this is that RAEM-Light calculates inputs in monetary terms: the portion of income to labor measures labor and the rest of output measures capital. Scarcely available capital data provides the rationale for this solution. This decision influences the size of output as it will be the result of labor and capital inputs defined above and this value will be definitely higher than its observed counterpart.

Both GDP predictions show some errors of similar size. The error in MACRO comes from the fact that output is generated by a separate output function that incorporates both supply and demand effects (equation 5.13) and not by the vintage capital production function directly. On the other hand error in the SCGE model is explained by the bias in estimating aggregate TFP level from regional productivity by way of averaging it. The error increases as inequalities in TFP levels increases (resulting from wider spatial inequaities of the distribution of CSF support).

Results in Tab. 6.1 suggest the following solution. Given that the ratios between SCGE and MACRO investment and employment are the same because of the same growth of labor and investment in both sub-models and also the same TFP level is used in both calculations correcting for the error occuring in MACRO in the respective SCGE calculation results in the „true" MACRO GDP in SCGE units.[23] As shown in the last column the resulting average percentage of predicting output in SCGE units in MACRO is almost 100. This is an evidence for the consistency between the two sub-models as to the estimation of aggregate output.

However, there is an increasing distortion between SCGE and MACRO outputs as the spatial inequality in TFP increases. This is because of the bias in the averaging process to get national TFP from regional values already detailed above. However, after a closer look at this issue distortion does not appear serious in real-word simulations. To show it some simulations were run with different spatial distributions of support. The size of distortion is measured by the mean absolute percentage error (MAPE) of predicting SCGE output by MACRO. This value is 1.90 if CSF funds are distributed according to the scenario suggested by the National Development Office (and treated in details in the next chapter). MAPE is 2.93 if Budapest gets 10 percent of total CSF funding whereas the respective values are 3.57 and 4.23 in case the share of the capital is 15 and 20 percents and the rest of the support is equally distributed among the 19 remaining counties. Thus even the quite unrealistic 15 and 20 percent distributions to Budapest result in a less than 5 percent MAPE that is not considered serious according to daily statistical experience.

[23] This practically means that for each year SCGE predicted values are divided by the percent of prediction in the MACRO model (and divided by 100).

6.3.2 Model sensitivity: Exogenous changes in technology, CSF support and parameters

In this section the behaviour of the model system to three types of exogenous changes are studied: changes related to Total Factor Productivity; the potential effects of expectations; the likely effects of changes in parameter values of some additional equations besides the ones covered in the previous two points. Additional to these issues the linearity of the system is examined. Results are reported in Tab. 6.2.

Regarding the first types of analyses results suggests that neither a change in the long run TFP growth rate nor changes in the coefficients of the policy variables in the TFP function exert major inpacts on any of the main endogenous variables. This is indicated by the low elasticity values in the table.

The second issue is the potential role of expectations. Although modeling the likely effects of changing expectations of economic actors is a difficult task first because formulating it alone requires specific approaches not necessary part of the toolbox of macroeconomic modeling and second because endogenizing expectations need long time series (much longer than this project is capable to build on) it is an interesting exercise. After searching through all the equations potentially related to expectations we ended up with the private consumption function as the most likely object of such an analysis. We focused on two variables such as the future change of disposable income (YDRH/YDRH(-1)) and the future interest rate (IRL). As detailed above it is found in the macro model that consumption increase remains below the increase of disposable income (as indicated by the negative sign of the change of disposable income variable) and substitution effects dominate in the intertemporal distribution of consumption as suggested by the negative sign of the interest rate variable.

To play around with the potential role of expectations a bit two potential effects of CSF interventions are formulated. First one possible outcome could be that consumers expect increasing burden in the future as increasing government expenditures could potentially result in higher tax rates. This might decrease the propensity to consume. It is indicated in our model with a higher negative value of the coefficient of the disposable income change variable. The other likely effect is increasing interest rates in the future that increase the substitution effect resulting in a higher negative value of the coefficient of IRL.

Tab. 6.2: Sensitivity analyses results: elasticity of main endogenous variables with respect to exogenous changes

	GDPV	DGDPV	CPV	ITV	ET	UNR	LFPR	DWSSE	DPDTY	PROD	CKL	ULCB	DPGDP	NLGQ
<u>1. TFP related analyses</u>														
Long run TFP growth rate	-0,07	-0,06	-0,08	-0,04	-0,05	-0,06	-0,04	-0,06	-0,09	-0,10	-0,07	-0,15	-0,08	-0,05
TFP: D(INFRAV(-1))	0,33	0,73	0,37	0,24	0,30	0,49	0,26	0,24	0,46	0,46	0,35	0,85	0,43	0,27
TFP: D(EDRDXV(-2))	0,36	0,65	0,38	0,28	0,39	0,54	0,31	0,73	0,50	0,39	0,35	0,36	0,48	0,30
<u>2. Potential role of expectations:</u>														
Private consumption: log(YDRH/YDRH(-1))	-0,12	-0,27	-0,39	-0,05	-0,18	-0,19	-0,21	0,00	0,00	0,01	0,01	-0,02	0,00	-0,22
Private consumption: IRL	0,11	0,10	0,22	0,11	0,25	-0,72	0,50	0,00	0,03	0,01	0,01	-0,01	0,00	-0,15
<u>3. Further coefficients</u>														
Output: LOG(WSSE / PGDPB / ELEFFU)	-0,21	0,71	0,10	2,37	-0,81	-4,84	-3,29	0,00	0,32	0,89	1,62	-1,97	-0,46	-0,65
Output : LOG(FDDV + XGSV - MGSV)	3,79	-2,85	1,89	-5,44	7,28	15,50	14,06	-0,05	-1,16	-2,90	-5,15	9,61	1,16	1,39
Wages: log(PCP)	0,21	0,25	0,14	0,04	0,71	0,17	0,27	-1,10	-0,04	-0,12	0,32	1,05	0,55	0,21
Wages: log(ELEFFU)	-0,32	-0,98	0,14	-0,05	-0,95	-0,94	-0,79	1,01	0,18	0,21	-1,48	-3,59	-2,59	-0,19
Labor Force: log(ETB/ETB(-1))	0,04	0,10	0,11	0,02	0,07	0,02	0,09	0,00	0,00	0,00	0,00	0,00	0,00	-0,05
Labor force: UNR	0,11	0,10	0,22	0,11	0,23	-0,72	0,48	0,00	0,03	0,01	0,01	-0,01	0,00	-0,15
<u>4. Linearity of the system</u>	-0,47	-0,48	-0,52	-0,44	-0,48	-0,50	-0,47	-0,50	-0,51	-0,51	-0,49	-0,51	-0,51	-0,43

Note: GDPV: percentage difference to baseline gross domestic product level; DGDPV: percentage point difference to baseline GDPV growth rate; CPV: percentage difference to baseline private consumption; ITV: percentage difference to baseline investment; ET: percentage difference to baseline employment; UNR: percentage point difference to baseline unemployment rate; LFPR: percentage point difference to baseline labor force participation rate; DWSSE: percentage point difference to baseline growth in wages; DPDTY: percentage point difference to baseline productivity growth, PROD: percentage difference to baseline productivity level; CKL: percentage difference to baseline unit capital-labor cost; ULCB: percentage difference to baseline unit labor cost, business sector; DPGDP: percentage point difference to baseline inflation rate; NLGQ: percentage point difference to baseline net government lending as percentage of GDP

We run two scenarios where coefficients of the variables (YDRH/YDRH(-1)) and IRL are increased. The effects on the main variables are presented in the form of elasticities in Tab. 6.2. It is suggested by the results that no significant effects could be resulted from changing expectations as we formulated them.

The table also exhibits sensitivity indicators of additional coefficient changes. It is seen that the the sensitivity is highest for the two coefficients of the output equation and for the rest of the estimated parameters the effects are basically negligible. However, the larger values in the output equation are observed for ratios such as unemployment rate (UNR) and labor force participation rate (LFPR) and for these the actual, percentage point changes are small (for the demand variable coefficient the respective percentage point changes are -0.24 and 0.24).

Although the model is not linear it might behave like a linear one. In case the system behaves in a linear manner the impacts of CSF interventions on macroeconomic variables do not depend on their baseline forecasted values. Thus the last experiment is about the linearity of the system. We experimented with decreasing the CSF expenditures with the same structure to half of it and studied the likely effects of this change. As shown in the last row of the table for all the variables the decrease of the effect is very close to 50 percent that is taken as an indicator of the linearity of the model[24].

[24] A simple example of a liner model is y = ax. If x is 50 in the baseline then if this is increased by 100 percent (a support of 50 let's call it scenario 1) the effect is a 100 percent higher y (i.e., ((100a-50a)/50a)) = 1). Similarly if support is decreased by 50 percent to 75 (scenario 2) the effect will be 0.5 (i.e., ((75a – 50a)/50a) = 0.5) that is a 50 percent smaller effect than that of scenario 1. This is very much the way the complex model system behaves. Furthermore in linear models changes in the model itself do not affect scenario predictions. In our simple example the increase of the parameter to 2a does not alter scenario results. This is 1 in scenario 1 (i.e., ((200a-100a)/100a) = 1) and 0.5 in scenario 2 (i.e., ((150a – 100a)/100a)= 0.5.)

7. Economic impacts of CSF development policy interventions on the Hungarian economy: A scenario analysis

7.1 The baseline scenario for the Hungarian economy, 2007-2017

Although we try to generate the baseline forecast under a set of realistic assumptions about the prospective future development of exogenous variables and policy parameters, to be realistic with regards to the forecasted values for each endogenous variable it is not so much an important thing than to create a projection that simply makes economic sense. The baseline scenario serves as basis for the ex-ante analyses of CSF. However, since the model behaves like a linear one, the results of these analyses are nearly not affected by the levels of the endogenous variables and are therefore also independent of how good they were forecasted.

The main assumptions regarding the projections of the exogenous variables and some policy parameters can be summarized as follows:

- The decline in total population, POPT, in the second half of the nineties seems to have come to a halt at the beginning of the century. We kept it, therefore, at its 2001 level.

- Also government employment, EG, is kept constant, because a more likely reduction, which would occur, if Hungary followed the corresponding guidelines of the European Commission, is hard to predict.

- Policy determined rates, such as direct and indirect taxes or social transfer rates are also kept at their 2001 values. In the same way some other policy variables of minor magnitude were treated, such as the property incomes paid and received by government, YPEPG and YPERG.

- In comparison to other accession and transformation countries the government investment ratio, IGV/GDPV, was in Hungary rather low in the nineties, but increased from 2.5 percent in 1995 continuously up to 3 percent in 2001. We assumed that this trend will continue and in 2010 a ratio of 4 percent be reached.

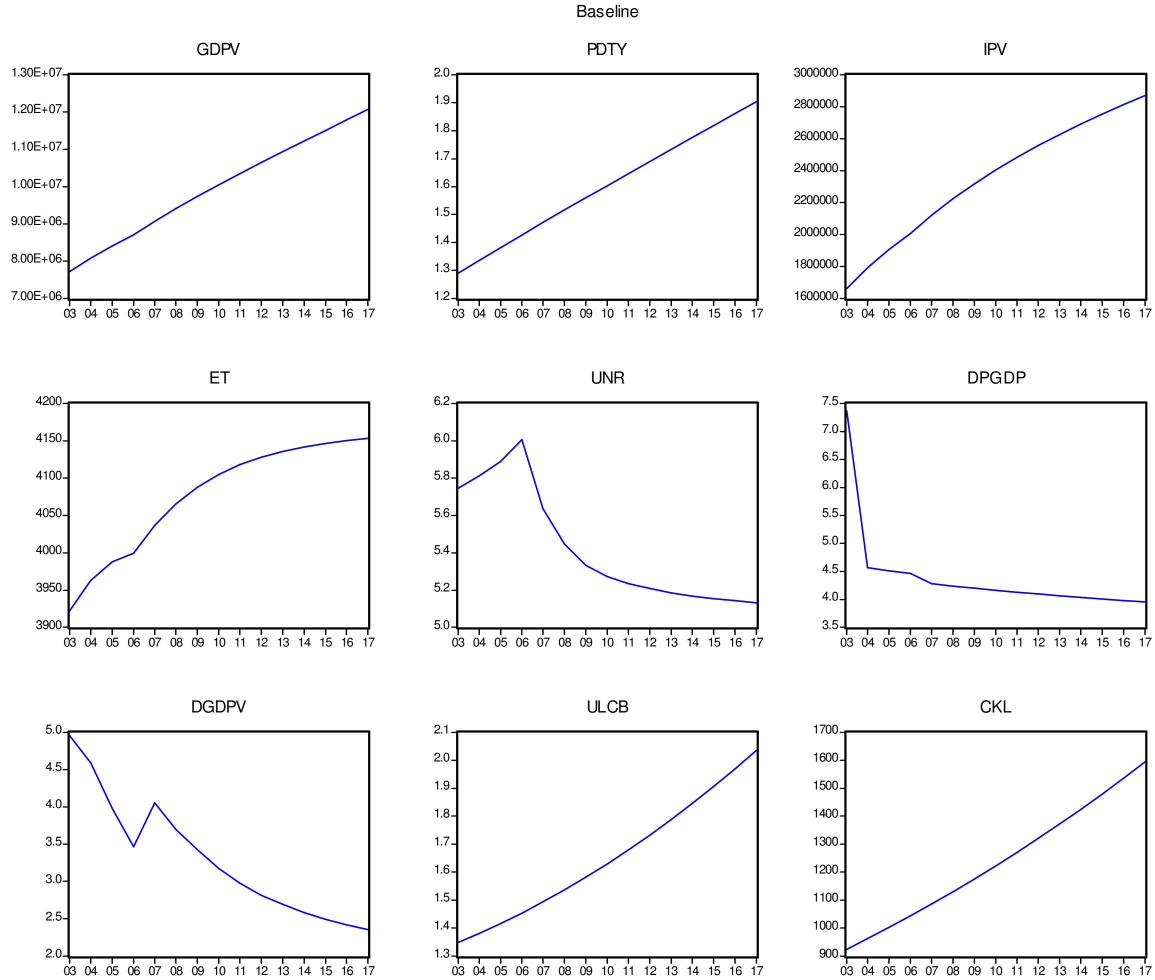


Fig. 7.1: The baseline scenario for main economic variables, 2003-2017

- The real interest rate remains constant, which means that a one-percentage point increase in the inflation rate increases the nominal interest rate also by one percent. Empirical research work corroborates this assumption for the long run (Deutsche Bundesbank 2001).

- As for world output, FGDPBV, which is in the model identical with the German gross domestic product of the business sector, an annual growth rate of 2 percent is assumed. Compared to the growth rates attained in the second half of the nineties in Germany, this is not a too pessimistic forecast.

Fig 7.1 exhibits the baseline scenario for main economic variables. For GDP (GDPV), labor productivity (PDTY) unit capital-labor cost (CKL) in the business sector and investment

(IPV) a continuous increase is assumed with an almost constant rate whereas for total employment the growth rate is decreasing. The optimistic feature of the baseline is completed by the decreasing trend of the unemployment rate (UNR). After 2004 a brake occurs in the decline of inflation rate (DGDPV). Unit labor cost (ULCB) seems to reach its highest level in the planning period.

7.2 Analyses of a scenario for the planning period 2007-2013

Table 7.1 lists the allocation of CSF support from EU sources according to the scenario provided by the National Development Office of the Hungarian government[25].

Table 7.1: CSF expenditures spent over the period of 2007 and 2015 (EU support)

	Infrastructure	Education	R&D	Total TFP-related	Investment	Demand side only	Total CSF
2007	144 930,96	84 161,73	31 487,96	260 580,64	50 874,26	72 017,26	383 472,17
2008	283 926,99	128 165,62	35 535,31	447 627,92	90 581,69	142 138,24	680 347,85
2009	302 313,38	135 196,93	35 535,31	473 045,61	97 436,95	145 487,48	715 970,05
2010	302 313,38	135 227,25	35 535,31	473 075,94	97 436,95	145 487,48	716 000,37
2011	302 313,38	135 227,25	35 535,31	473 075,94	97 436,95	145 487,48	716 000,37
2012	302 313,38	135 227,25	35 535,31	473 075,94	96 604,52	145 487,19	715 167,65
2013	301 466,06	129 116,26	33 997,40	464 579,72	90 011,38	145 404,05	699 995,14
2014	276 195,18	103 748,84	22 032,62	401 976,64	72 872,25	140 542,95	615 391,84
2015	138 046,47	65 825,61	19 523,18	223 395,27	39 757,96	70 505,11	333 658,34
	2 353 819,17	1 051 896,74	284 717,71	**3 690 433,62**	**733 012,92**	**1 152 557,25**	**5 576 003,78**

Note: All figures are in millions of 2004 Hungarian Forints

[25] Note that in the followings we analyse the macro and regional effects generated by support from EU funds. This means that Hungarian co-finance is being subtracted from the total of NDP II expenditures. The procedure to subtract Hungarian co-financing was governed by the principle of additionality. According to this the government should not spend less in the areas where the EU supports the country than she spent during the 2004-2006 period on average. This basically means that Hungarian co-financing (which is on average 15 percent of the total support of the projects) covers government spending that would have been done without support from the EU. Since these expenditures have already been taken care of in the model baseline this amount is subtracted from total NDP expenditures. With respect to investment support we relied on a government document that summarises the experience of NDP I in Hungary (GVOP 2006). According to this on average 68 percent of the support generates investment.

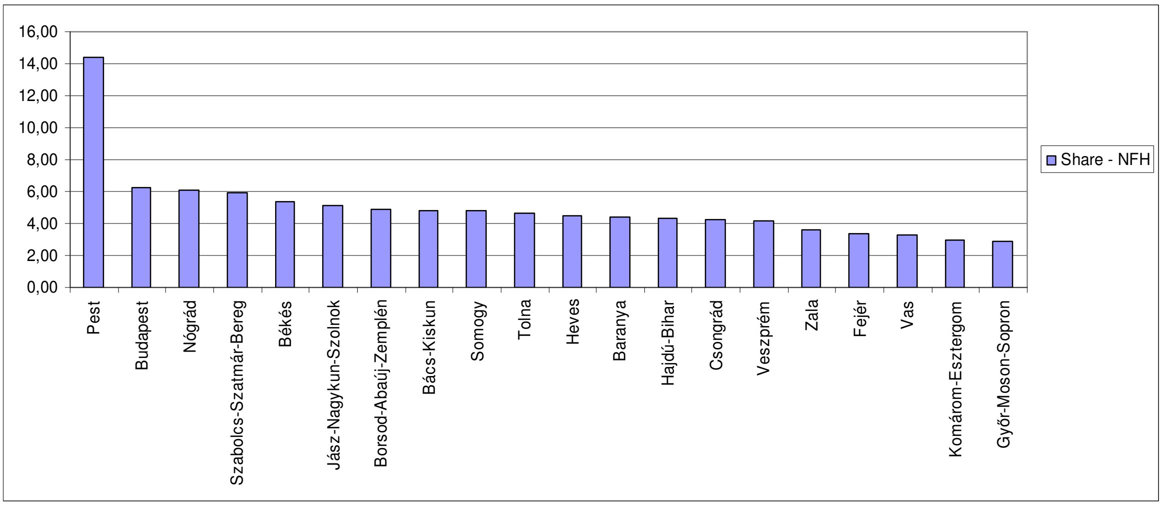


Figure 7.1: The spatial distribution of CSF support over the period of 2007-2015

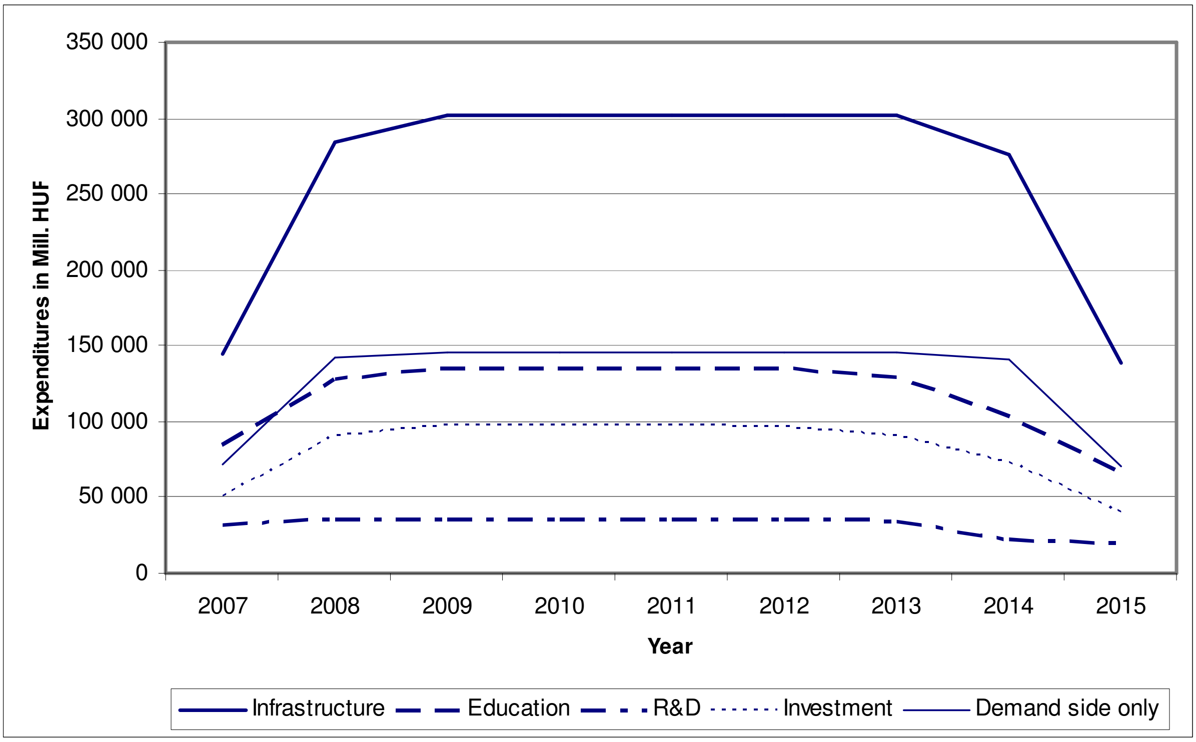


Figure 7.2: The planned distribution of CSF expenditures according to the classification used in the model (EU support)

Spatial and temporal features of the expenditures are presented in Figures 7.1 and 7.2. The scenario favors the Budapest agglomeration as more than 20 percent of expenditures are concentrated in Pest county (14 percent) and in Budapest. With our modeling approach the likely (static and dynamic) agglomeration effects can be accounted for as in GMR what matters is not only the size of expenditures but also their spatial distribution. These effects are assumed significant at this level of concentration of CSF funds. The remaining part of the expenditures are planned to be spent almost equally among the 18 counties with some variation in it as two developing counties (Nógrád and Szabolcs-Szatmár-Bereg) receive the same share (6 percent) as the capital and two well-performing counties (Komárom-Esztergom and Győr-Moson-Sopron) are provided with about 2.5 percent of the total spending. As to the temporal characteristics of planned CSF expenditures after a steep increase from 2007 to 2008 the level of expenditures in all categories remains unchanged until 2014 when a sharp decline to 2015 starts.

The size of expenditures is considerable as it is compared to Hungarian GDP. Total CSF expenditures (including both EU resources and Hungarian cofinancing) account for about 4 percent which is a relatively high percentage compared to international experiences. Perhaps Germany in the period of 1994-2000 could come closest as the respective share was about 5 percent there (Schalk and Varga 2004).

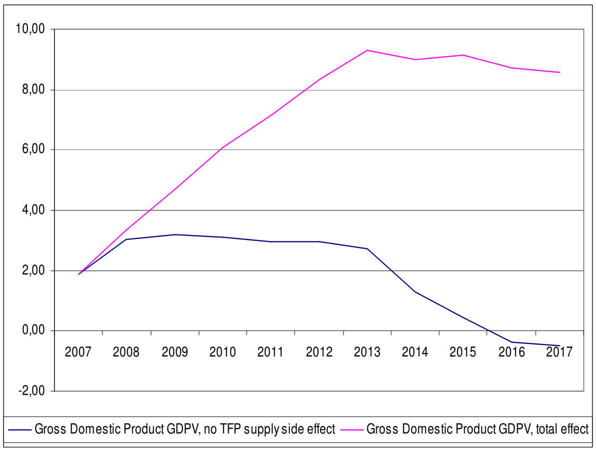
The structure of expenditures especially taking into account the TFP-related ones is also worth detailing. Compared to 2003 spendings (the last year with no CSF intervention in Hungary) expenditures in infrastructure are 36 percent higher annually on average during the period of 2007-2015 whereas the corresponding figures for education and R&D are 11 and 25 percents. On average with CSF support Hungary spends 22 percent more on TFP-related instruments than without the planned interventions.

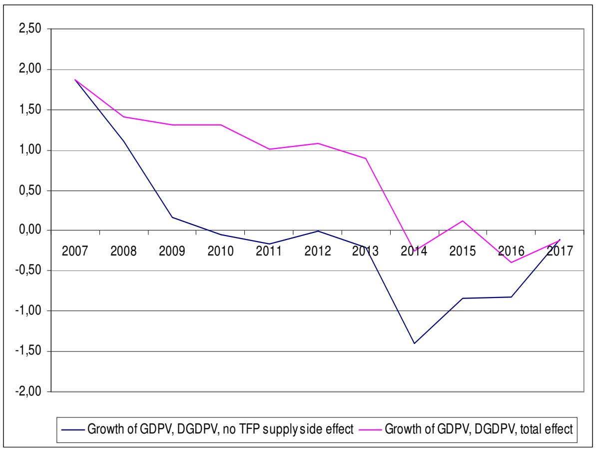
We focus on the aggregate national level impacts in this section. Space constraints do not allow us to present national sectoral and county level aggregate and sectoral results. These can be studied in details by using the complex model software. Table 7.2 and figure 7.3 exhibit the results of the scenario on main macroeconomic variables. In the table the total CSF effects are communicated either in the form of percentage changes compared to the baseline (i.e., the situation without CSF interventions) or in the form of percentage point changes relative to the baseline. Variable acronyms are explained in the note of the table as well as the type of measure applied (i.e., percentage or percentage point differences). The figures provide further information with respect to the supply and demand effects on the main macro variables.

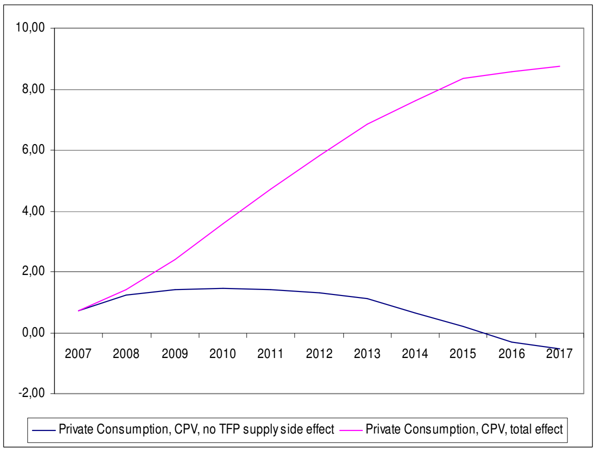
Table 7.2: Estimated effects of CSF interventions on main macroeconomic variables relative to baseline (EU support)

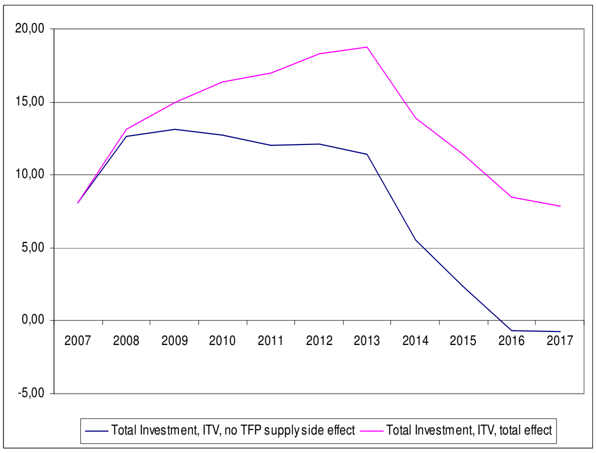
	GDPV	DGDPV	CPV	ITV	ET	UNR	LFPR	DWSSE	DPDTY	PROD	CKL	ULCB	DPGDP	NLGQ
2007	1,89	1,87	0,70	8,06	1,63	-0,95	0,38	0,00	0,25	0,03	-0,40	-0,09	-0,38	0,71
2008	3,33	1,40	1,41	13,07	2,81	-1,37	0,83	0,43	0,26	0,13	-0,88	0,10	-0,35	1,32
2009	4,69	1,31	2,41	15,00	3,73	-1,60	1,24	1,64	0,42	0,44	-1,67	1,19	-0,34	1,92
2010	6,07	1,31	3,59	16,34	4,47	-1,75	1,60	1,85	0,60	0,97	-2,60	2,17	-0,47	2,48
2011	7,15	1,01	4,70	17,00	4,81	-1,71	1,85	1,52	0,68	1,65	-3,50	2,58	-0,58	2,86
2012	8,32	1,08	5,81	18,31	5,13	-1,73	2,03	1,41	0,79	2,45	-4,42	2,70	-0,69	3,20
2013	9,29	0,90	6,86	18,73	5,17	-1,63	2,13	1,45	0,85	3,37	-5,37	2,69	-0,72	3,43
2014	9,01	-0,26	7,63	13,89	4,08	-0,92	1,93	1,43	0,79	4,40	-6,31	2,52	-0,59	3,21
2015	9,14	0,12	8,33	11,42	3,29	-0,62	1,65	1,23	0,87	5,49	-7,12	2,10	-0,67	2,99
2016	8,71	-0,39	8,58	8,45	2,10	-0,12	1,24	0,55	0,77	6,55	-7,66	1,08	-0,59	2,53
2017	8,58	-0,12	8,75	7,86	1,24	0,10	0,85	0,07	0,72	7,53	-8,11	-0,24	-0,61	2,10

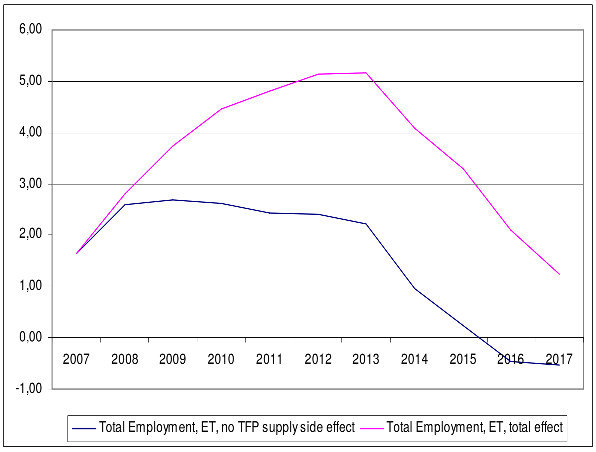
Note: GDPV: percentage difference to baseline gross domestic product level; DGDPV: percentage point difference to baseline GDPV growth rate; CPV: percentage difference to baseline private consumption; ITV: percentage difference to baseline investment; ET: percentage difference to baseline employment; UNR: percentage point difference to baseline unemployment rate; LFPR: percentage point difference to baseline labor force participation rate; DWSSE: percentage point difference to baseline growth in wages; DPDTY: percentage point difference to baseline productivity growth, PROD: percentage difference to baseline productivity level; CKL: percentage difference to baseline unit capital-labor cost; ULCB: percentage difference to baseline unit labor cost, business sector; DPGDP: percentage point difference to baseline inflation rate; NLGQ: percentage point difference to baseline net government lending as percentage of GDP.

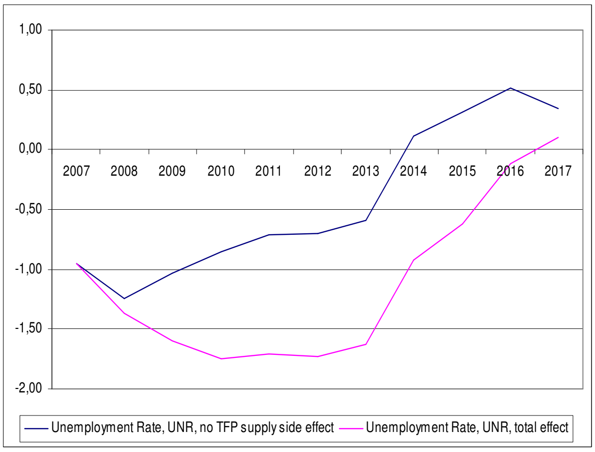

10,00
8,00
6,00
4,00
2,00
0,00
-2,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Gross Domestic Product GDPV, no TFP supply side effect
Gross Domestic Product GDPV, total effect

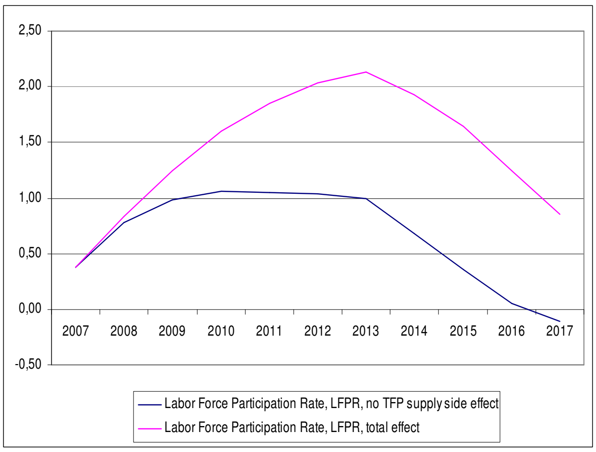

2,50
2,00
1,50
1,00
0,50
0,00
-0,50
-1,00
-1,50
-2,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Growth of GDPV, DGDPV, no TFP supply side effect
Growth of GDPV, DGDPV, total effect

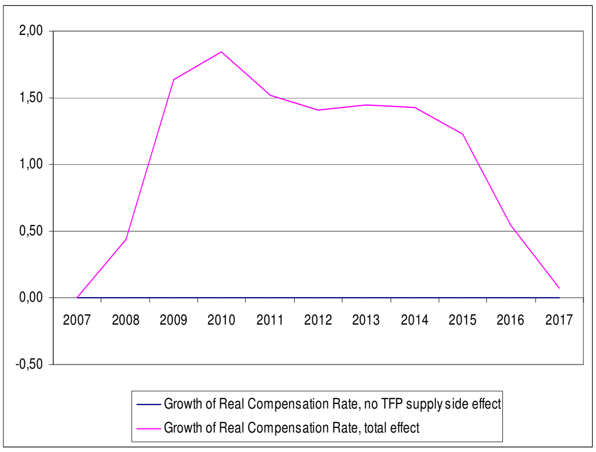

10,00
8,00
6,00
4,00
2,00
0,00
-2,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Private Consumption, CPV, no TFP supply side effect
Private Consumption, CPV, total effect


20,00
15,00
10,00
5,00
0,00
-5,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Total Investment, ITV, no TFP supply side effect
Total Investment, ITV, total effect


6,00
5,00
4,00
3,00
2,00
1,00
0,00
-1,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Total Employment, ET, no TFP supply side effect
Total Employment, ET, total effect


1,00
0,50
0,00
-0,50
-1,00
-1,50
-2,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Unemployment Rate, UNR, no TFP supply side effect
Unemployment Rate, UNR, total effect


2,50
2,00
1,50
1,00
0,50
0,00
-0,50
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Labor Force Participation Rate, LFPR, no TFP supply side effect
Labor Force Participation Rate, LFPR, total effect


2,00
1,50
1,00
0,50
0,00
-0,50
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Growth of Real Compensation Rate, no TFP supply side effect
Growth of Real Compensation Rate, total effect

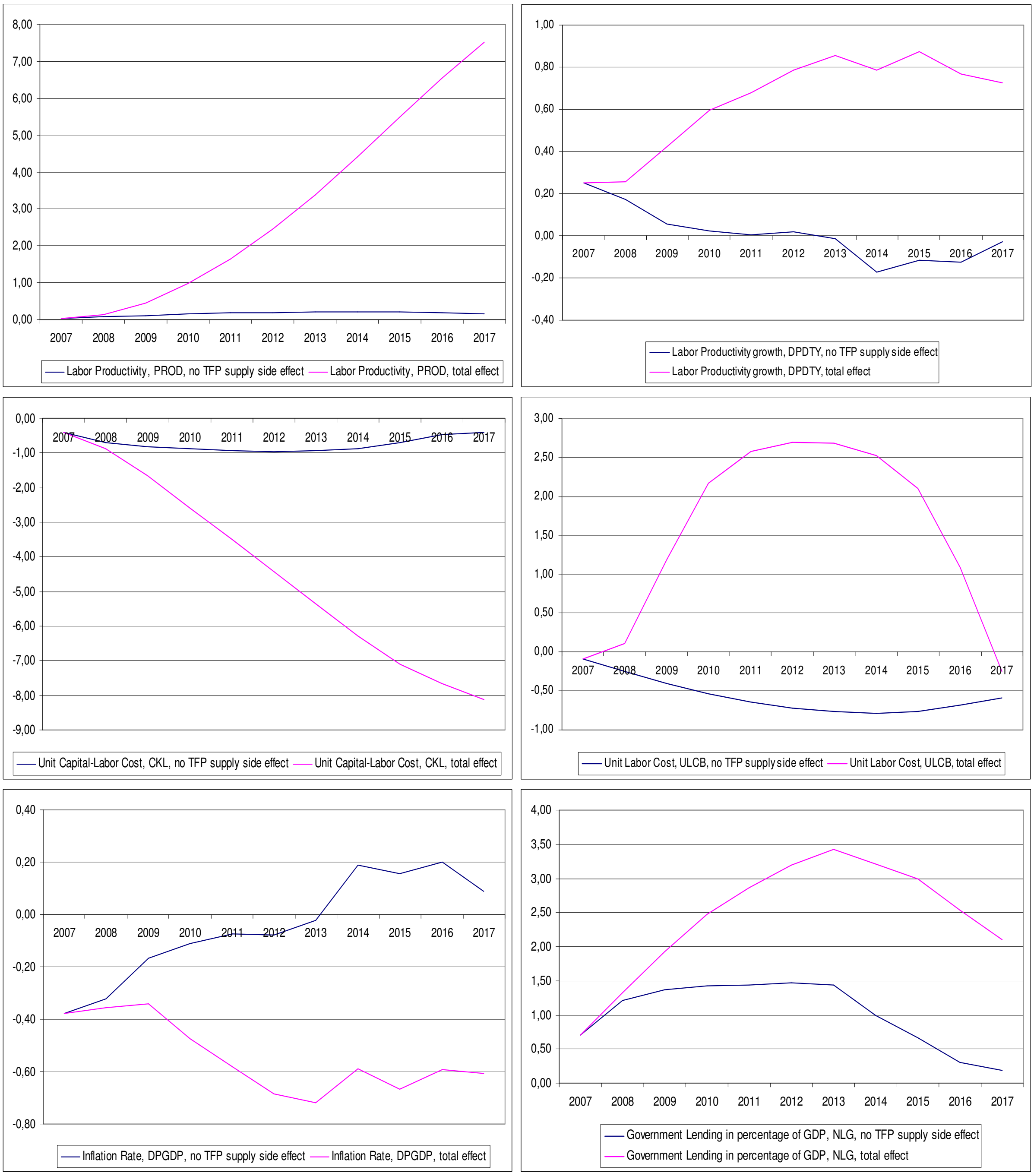


Figure 7.3: Demand and supply side impacts on main economic variables relative to the baseline (EU support, continued from previous page)

Demand side effects are formulated in the model as increased government investment (infrastructure investments), increased transfer payments (expenditures on human resources) and increased investments (investment support). The supply side is affected by TFP changes (resulting from infrastructure investments and supports for education, training and R&D) on the one hand and by less costly investments (i.e., support for productive structures decreases costs and potentially increase production).

The remaining part of this section is devoted to analyzing the results presented in Table 7.2 and Figure 7.3.

To measure the effects on output impacts on GDP level and GDP growth rate are presented in the Table and in the Figure. The difference to baseline GDP level constantly increases until 2015 then it seems to be stabilized at the value of nearly 9 percent. On average the increase in GDP level is about 7 percent. This is a two times higher effect than was calculated in the first planning period (2004-2006) for Hungary (Schalk and Varga 2004) which is understandable as the share of expenditures in GDP is about doubled in the second period. The 7 percent average impact figure comes also quite close to the German 1996-2000 experience when the 5 percent GDP share of CSF support resulted in a 6.5 percent average output effect.

It becomes clear from the Figure that most of the output effects come from the supply side. The demand side effect is strong in the beginning of the period than it stays at about 3 percents until the expenditures decrease in 2014 and 2015. In contrast to the demand side effect from the supply side a more prevalent and lasting impact is experienced. Productivity growth resulting from TFP increase and investment support exerts significant effects on output. The impact increases with a constant rate until 2014 (mainly due to the constant level of spendings on productivity-related policy instruments as shown in Figure 7.2) then it seems to reach a stable level of nearly 9 percent. Figure 7.3 also shows that while demand side effects decrease and almost vanish after the support is stopped supply side impacts prevail as the influence on productivity stays for longer time.

The effect on GDP growth rate reflects the same pattern as what we learned while studying the level impacts. The sharp increase of GDP growth rate change to 1.87 percentage point in 2007 is due to the demand schock. The demand effect on the growth rate then strongly decreases after 2008 and becomes even negative after 2010. This pattern perfectly repeats the one detailed when the demand side effect is explained. The same is true for the total effect on GDP growth rate. It remains around 1 percent during most of the planning period then it tends to fade away after 2015. Thus the almost zero growth effect from the supply side after the end of CSF support is in accordance with the stable level effect. The average total effect on GDP growth rate is 0.75 percentage point.

The pattern of private consumption change is pretty similar to the GDP level effect. Most of it is a result of supply side interventions. With respect to investment the “no TFP supply side effect” does mean that both demand side and supply side (in the form of cheaper and increased investments) impacts are in force. There is a technical reason why we cannot separate them from each other in simulations. The supply-demand side impact shows a strong increase in 2007 and 2008 then it further increase until 2014 and with the end of CSF internventions it shows a sharp decline to the long lasting effect of about 8 percent.

The employment effect of CSF interventions according to the scenario analysed here is meqaningful (about 5 percent at the peak in 2014 and about 3.5 percent on average). This is due to the particular mixture of output, substitution and productivity effects working behind the scene. The output effect is partly due to the supply side (i.e., increasing productivity might increase output since unit cost is lower – this effect comes from both TFP increase and investment support) and partly resulted from the demand side (in the form of increased demand). Taken together of these effects they result in an increase in employment. Contrary to the output effects the substitution and the productivity impacts are counter-employment boosting. This is first because investment support decreases the cost of capital motivating firms to replace labor with productive structures and second because increased productivity via TFP support reduces costs of the same level of output that could motivate firms to produce less with less labor employed. As shown in the figure most of the impacts come from the demand side (output effect) and this vanishes after support is no longer available. The similar pattern can be observed for labor force participation rate as well.

As to unemployment the supply and demand side effects are quite close to each other but it is clear that the higher-than baseline unemployment rate is dominantly caused by supply side impacts. After taking into account that the decline in labor force participation is less dramatic than the decrease in employment it becomes clear that higher unemployment when interventions are no longer in effect is a result of these patterns. Increase in wages is significant in most part of the intervention period and after its end wage growth declines close to zero. Most of these effects are caused by productivity increase.

After a sharp increase in the beginning of the period the impact on labor productivity grows with a constant rate as a result of the supply side effects mainly. Demand and supply side influence labor productivity growth differently. While the demand side effect stays and then vanishes after the support is stopped the supply side impact increases for most of the period and seems to approach a longer term constant effect after 2014. These patterns repeat the one studied in more detail while the impacts on the GDP growth rate are examined.

The increase in unit labor cost compared to baseline is mainly due to increased productivity. It appears that higher than-baseline inflation rate after 2013 is the result of this demand side effect coming from increasing wages and consumption. The total effect on net government lending is positive during the whole period which means that CSF support decreases government deficit mainly due to the supply side effects.

Appendix 7 presents the results when the total amount of NDP support (i.e., EU and Hungarian co-financing together) is used for impact analysis. Due to the quasy-linear nature of GMR, the effects are slightly higher than the ones presented in this section.

7. Summary and conclusions

This report presented a detailed description of GMR-Hungary the complex macro- and regional model built for development policy impact analysis for the Hungarian National Development Agency. The main distinguishing features of the model can be summarized as follows:

- strong supply side orientation
- direct modeling of technological change
- incorporating geography (agglomeration) effects in the analysis
- the capacity of providing both macro and regional level analyses
- a four sector approach (industry, agriculture, services and government)
- the model is packaged in a user-friendly software environment.

GMR-Hungary has been developed by an international consortium that was necessary to establish given the extremely complex nature of the knowledge inherent in the system. The model is built on four strands of recent economic literatures: the new economic geography, the endogenous growth theory, the systems of innovation school and the geography of innovation field. According to the complex nature of the problem GMR is a coherently built system of three sub-models: the TFP sub-model (responsible for calculating static productivity effects) the SCGE sub-model (with the task of simulating long run dynamic effects on the spatial distribution of technology, labor, capital, wages and output) and the MACRO sub-model (which is incorporated into the system to generate likely macroeconomic effects of development policy interventions).

Additional to describing GMR-Hungary this report provided a detailed analysis of the likely effects of a scenario worked out by the Hungarian government for spending funds during the period of the National Development Plan II of the country.

Besides that GMR-Hungary extends the limits of development policy impact analyis significantly the model has several limitations directing towards further developments of its system. These include

- the crude account for agglomeration with a simple employment size measure;
- the limitations of TFP as the index of the development of technology (Hulten 2000);
- the limits of the knowledge production function approach in capturing knowledge spillover effects (Feldman 2000);
- the simplistic modeling of the migration of capital over space in the SCGE sub-model.

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Appendices

Appendix 1: Equation system - Macro and TFP sub-models[26]

Variable name	Variable description	Equation
	Endogenous variable	
		I. The supply side
		1. Business sector and government
ETB	Employment of the business sector	ETB = ETB(-1) * EXP(- 0.6462765982 + LOG(GDPBV / GDPBV(-1)) - 0.1 * (LOG(ETB(-1) / GDPBV(-1)) + (1 - XTAU) * LOG((WSSE / XTAU) / (UCC / (1 - XTAU))) + XTAU * LOG(ELEFFU)) + 0.01838048857 * (DUMMY_95_96 + DUMMY_99_02) - 0.0346201138 * DUMMY_92_94 - 0.01127018745 * DUMMY_93)
IPV	Private total fixed capital formation, volume	IPV = IPV(-1) * EXP(-0.4640446414 - 0.1313832514 * (LOG(IPV(-1) / GDPBV(-1)) - (1. / 0.1) * LOG(GDPBV / GDPBV(-1)) - XTAU * LOG((WSSE / XTAU) / (UCC / (1. - XTAU))) + XTAU * LOG(ELEFFU)) + 0.0565779131 * (DUMMY_94_96_98_99) - 0.03849758663 * DUMMY_95_01_02 - 0.02338901205 * DUMMY_97_98)
GDPBV	Gross domestic product, business sector, volume, factor cost	GDPBV = EXP(7.153939065 - XTAU * LOG(WSSE / PGDPB / ELEFFU) + 0.8096641143 * LOG(FDDV + XGSV - MGSV) + 0.02891037751 * DUMMY_98_00_01)
WSSE	Compensation rate of the business sector	WSSE = EXP(6.79515674 + XTAU * LOG(ELEFFU) + LOG(PCP) - 0.09506299279 * (DUMMY_99_00))
UCC	User cost of capital	UCC=PIT*(IRL-DPGDP+10)
CKL	Unit capital-labor costs	CKL=EXP(XTAU*(LOG(WSSE/XTAU) -LOG(ELEFFU)) +(1.-XTAU)*LOG(UCC/(1.-XTAU)))
PROD	Labor productivity of the business economy	PROD=GDPBV/ETB
ULCB	Unit labor costs in the business sector	ULCB=(WSSE*ETB)/GDPBV
GDPV	Gross domestic product, volume, market prices	GDPV=GDPBV+CGW/PCGW+NITV+CFKG/PIT
CGW	Government final wage consumption expenditure, value	CGW=WRG*EG
WRG	Compensation rate of government employees	WRG=WRGQ*WSSE
NITV	Net indirect taxes, volume	NITV=XNITV*(GDPV-CGW/PCGW)
GVAV	Gross value added, volume	GVAV= GDPV-NITV+FISIMV
GVABV	Gross value added of business sector, volume	GVABV=GVAV-CGW/PCGW-CFKG/PIT

[26] On the basis of Schalk and Varga (2004) compiled by Onno Hoffmeister.

GDPB	Gross domestic product of business sector, value, factor costs	GDPB=PGDPB*GDPBV
GDP	Gross domestic product, value, market prices	GDP=GDPB+CGW+NIT+CFKG
NIT	Net indirect taxes, value	NIT=TIND-TSUB
TSUB	Subsidies	TSUB=TSUBQ*GDP
TIND	Indirect taxes, value	TIND=TINDQ*FDD
CFKG	Government consumption of fixed capital, value	CFKG= 0.043557 *GDP

2.Sectoral wages

WSSE1	Compensation rate in agriculture	WSSE1 = EXP(1.125048364 + 0.8114342375 * LOG(WSSE)
WSSE2	Compensation rate in industry	WSSE2 = EXP(0.5603170035 + 0.9138255462 * LOG(WSSE))
WSSE3	Compensation rate in services	WSSE3 = EXP(-0.4716353644 + 1.077508674 * LOG(WSSE))

3. Labor market

ET	Total employment	ET=ETB+EG
EEP	Dependent employment of the business sector	EEP=ET-ES-EG
ES	Self-employed	ES=ESQ*ETB
EE	Dependent employment	EE=EEP+EG
LF	Labor force	LF = POPT * (0.1254955234 + 0.8184106563 * (LF(-1) / POPT(-1)) + 0.1884826701 * LOG(ETB / ETB(-1)) - 0.00263766064 * UNR(-1))
UN	Unemployment	UN=LF-ET
UNR	Unemployment rate	UNR=UN*100./LF
LFPR	Labor force participation rate	LFPR=LF/POPT*100.0
PDTY	Labor productivity of the total economy	PDTY=XPDTY*(GDPV/ET)

II. The demand side

1. Volumes

FDDV	Final domestic expenditure, volume	FDDV=CPV+CGV+ITV
CPV	Private final consumption expenditure, volume	CPV = YDRH * EXP(0.067187 + 0.745648 * LOG(CPV(-1) / YDRH(-1)) - 0.588445 * LOG(YDRH / YDRH(-1)) - 0.005051 * IRL + 0.02838 * DUMMY94)
CGV	Government final consumption expenditure, volume	CGV=CG/PCG

ITV	Gross total fixed capital formation, volume	ITV=IPV+IGV
IGV	Government fixed capital formation, volume	IGV=IG/PIT
TDDV	Total domestic expenditure, volume	TDDV=FDDV+ISKV
ISKV	Increase in stocks, volume	ISKV=ISK/((TDD-FDD)/(TDDV-FDDV))
FBGSV	Net exports of goods and services, volume	FBGSV=GDPV-TDDV
XGSV	Exports, volume	XGSV = xgsvqr * GDPV Where xgsvqr =0.856
MGSV	Imports, volume	MGSV = mgsvqr_1 * GDPV Where mgsvqr_1 =mgsv/gdpv for the 1995-2003 period

2. Values

FDD	Final domestic expenditure, value	FDD=CP+CG+IT
CP	Private final consumption expenditure, value	CP=CPV*PCP
CG	Government final consumption expenditure, value	CG=CGW+CGNW
IT	Gross total fixed capital formation, value	IT=IP+IG
IP	Private total fixed capital formation, value	IP=IPV*PIT
TDD	Total domestic expenditure, value	TDD=FDD+ISK
FBGS	Net exports of goods and services, value	FBGS=GDP-TDD

3. Deflators

LLRPCP	Domestic expenditure excl. government wages, deflator, log	LLRPCP=(1/(GDPBV+NITV))*(GDPBV *LOG(PGDPB/PGDPB(-1))+NITV *LOG((NIT/NITV)/(NIT(-1)/NITV(-1))))
PGDPB	Gross domestic product, business sector, deflator	PGDPB = EXP(-2.184324816 + 0.3752619755 * LOG(CKL) + (1-0.3752619755)*LOG(PGDPB(-1)) + 0.05440570567* DUMMY_96_97 - 0.05222860349 * DUMMY_99)
DPGDPB	Inflation rate of GDPB	DPGDPB=LOG(PGDPB/PGDPB(-1))*100
PCGW	Government final wage consumption expenditure, deflator	PCGW=PCGW(-1)*WRG/WRG(-1)
PCP	Private final consumption expenditure, deflator	PCP = EXP(0.06613158286 + 0.4083546987 * LOG(PGDPB) + 0.2302822653 * LOG(PMGS) + (1 - 0.4083546987 - 0.2302822653) * LOG(PCP(-1)) + 0.01583059211 * DUMMY_95_96)
DPCP	Inflation rate of PCP	DPCP=LOG(PCP/PCP(-1))*100

PIT	Gross total fixed capital formation, deflator	PIT = EXP(-0.006428406909 + 0.6508908841 * LOG(PGDPB) + 0.3718922778 * LOG(PMGS) + (1 - 0.6508908841 - 0.3718922778) * LOG(PIT(-1)) - 0.02929867509 * (DUMMY_00_01 + DUMMY_94))
PCG	Government final consumption expenditure, deflator	PCG=PCGQ*PGDPB
PCGNW	Government final non-wage consumption expenditure, deflator	PCGNW=PCGNW(-1)*EXP(-0.034202 +LOG(PCG/PCG(-1)))
PFDD	Final domestic expenditure, deflator	PFDD=(CP+CG+IT)/(CPV+CGV+ITV)
PTDD	Total domestic expenditure, deflator	PTDD=TDD/TDDV
PGDP	Gross domestic product, market prices, deflator	PGDP=GDP/GDPV
DPGDP	Inflation rate of GDP	DPGDP=LOG(PGDP/PGDP(-1))*100
PTE	Total expenditure exclusive government wage consumption, deflator	PTE=(TDD-CGW)/(TDDV-CGW/PCGW)

III. Income distribution

YDH	Household disposable income, value	YDH=YRH-TYH-TRPH
YRH	Current receipts of households, value	YRH=WSSS+YOTH+TRRH
WSSS	Compensation of employees, value	WSSS=WSSE*EEP+CGW
YOTH	Self-employment & property income received by households, value	YOTH=YSE+YPE
YSE	Self-employment income received by households, value	YSE=YSEQ*ES*WSSE
YPE	Property income received by households, value	YPE=YPEQ*PROF
PROF	Profits and other non-wage income, value	PROF=GDP-WSSS-YSE-NIT
TRRH	Current transfers received by households, value	TRRH=SSPG+TRPG+ZCS001
SSPG	Social security benefits paid by government	SSPG=0.476907*WSSE*UN+SSPG(-1)
TYH	Direct taxes on households, value	TYH=TYHQ*YRH
TRPH	Total transfers paid by households, value	TRPH=TROPH+TRSSH
TROPH	Non-social security transfers paid by households, value	TROPH=TROPHQ*YRH
TRSSH	Social security contributions by households, value	TRSSH=TRPBTH+TRPESH+TRPGSH

TRPBTH	Private employers social security contributions	TRPBTH=TRPBTHQ*(WAGE-WAGEG)
TRPGSH	Government employers contributions to social security, value	TRPGSH=TRPGSHQ*WAGEG
TRPESH	Employees & self-employed contributions to social security, value	TRPESH=TRPESHQ*(WAGE-WAGEG+YSE)
WAGE	Wages, value	WAGE=WSSS-TRPBTH-TRPGSH
WAGEG	Wages of the government sector, value	WAGEG=CGW-TRPGSH
YPH	Current disbursements of households, value	YPH=TYH+TRPH+CP
SAVH	Household saving, value	SAVH=YRH-YPH
SRATIO	Household saving ratio	SRATIO=SAVH*100/YDH
YDRH	Household disposable income, real	YDRH=YDH/PCP
TYB	Direct taxes on business, value	TYB=TYBQ*PROF
TY	Total direct taxes, value	TY=TYH+TYB
YRG	Government current receipts, value	YRG=TY+TRSSH+TRRG+TIND+YPERG
YPG	Government current disbursements, value	YPG=CG+YPEPG+SSPG+TRPG+TSUB
SAVG	Government saving, value	SAVG=YRG-YPG
CAPOG	Net capital outlays of the government, value	CAPOG=IG-KTRRG-CFKG
NLG	Government net lending, value	NLG=SAVG-CAPOG
YPGT	Government total disbursements, value	YPGT=YPG+CAPOG
NLGQ	Government net lending, percentage of GDP	NLGQ=NLG/GDP*100
YPGTQ	Government total disbursements, percentage of GDP	YPGTQ=YPGT/GDP*100
YRGQ	Government current receipts, percentage of GDP	YRGQ=YRG/GDP*100
		IV. Total Factor Productivity (TFP)
ELEFFU	Labor efficiency of the business sector	ELEFFU=EXP((1./XTAU)* 0.017441*TIME)
CTFPGR	County TFP growth	DTFP2 = -1.038934975 - 0.2587264068*DTFP2(-2) + 8.836649401e-005*PAT(-2) + 0.08263333562*(FDISH(-3)) + 2.112574087e-006*D(INFRAV(-1)) + 5.630818475e-006*D(EDRDXV(-2)) - 0.06097097103*DUM99
DNTFPGR	Change of national TFP growth due to CSF policy	DNTFPGR=$\sum_i$CEMP$_i$*d(CTFPGR$_i$)
TFP	Total factor productivity	TFP=ELEFFU^{XTAU}
CSFTFP	Total factor productivity, CSF policy effects included	CSFTFP=TFP*EXP(DNTFPGR)

Appendix 2: Variables – Macro and TFP sub-models[27]

A II.1 : Exogenous variables

Variable name	Variable description
CGNW	Government final non-wage consumption expenditure, value
EG	Government employment
ESQ	Self-employment share in business economy
EUGDPV	Gross domestic product in the EU15, volume
FGDPBV	Foreign gross domestic product, business sector, volume, factor cost
FISIMV	FISIM, volume
IG	Government fixed capital formation, value
IRL	Long term interest rate on government bonds
ISK	Increase in stocks, value
KTRRG	Net government capital transfers received
PCGQ	Ratio of government final consumption expenditure deflator to GDP deflator
POPT	Working-age population
SHET1	Share of agriculture in total business employment
TIME	Time trend (0 in 1995)
TINDQ	Total tax ratio of indirect taxes
TPCOST	Transport costs
TROPHQ	Share of non-social security transfers, paid by households, in their income
TRPBTHQ	Share of private employers' contribution to social security and pension fonds in private sector wages
TRPESHQ	Share of employees & self-empl. social security contributions in market income
TRPG	Other current transfers paid by government
TRPGSHQ	Share of government employers social security contributions in public sector wages
TRRG	Other current transfers received by government, value
TSUBQ	Share of subsidies in GDP
TYBQ	Total tax ratio of direct taxes on profits
TYHQ	Total tax ratio of direct taxes on households
WRGQ	Compensation rate of government employees relative to total economy
XNITV	Coefficient
XPDTY	Coefficient
XTAU	Coefficient
YPEQ	Share of property income in profits
YPEPG	Property income paid by government, value
YPERG	Property income received by government, value
YSEQ	Share of income from self-employment in total income
ZCS001	Non-social security transfers received by households

[27] On the basis of Schalk and Varga (2004) compiled by Onno Hoffmeister.

A II.2 : Endogenous variables

Variable name	Variable description
CAPOG	Net capital outlays of the government, value
CFKG	Government consumption of fixed capital, value
CG	Government final consumption expenditure, value
CGV	Government final consumption expenditure, volume
CGW	Government final wage consumption expenditure, value
CKL	Unit capital-labor costs
CP	Private final consumption expenditure, value
CPV	Private final consumption expenditure, volume
DPCP	Inflation rate of PCP
DPGDP	Inflation rate of GDP
DPGDPB	Inflation rate of GDPB
EE	Dependent employment
EEP	Dependent employment of the business sector
ELEFFU	Labor efficiency of the business sector
ES	Self-employed
ET	Total employment
ETB	Employment of the business sector
ET1	Employment in agriculture
ET2	Employment in industry
ET3	Employment in services
FBGS	Net exports of goods & services, value
FBGSV	Net exports of goods & services, volume
FDD	Final domestic expenditure, value
FDDV	Final domestic expenditure, volume
GDP	Gross domestic product, value, market prices
GDPB	Gross domestic product of the business sector, value, factor costs
GDPBV	Gross domestic product, business sector, volume, factor cost
GDPV	Gross domestic product, volume, market prices
GVAV	Gross value added, volume
GVABV	Gross value added of the business sector, volume
GVAV1	Gross value added in agriculture, volume
GVAV2	Gross value added in industry, volume
GVAV3	Gross value added in services, volume
IGV	Government fixed capital formation, volume
IP	Private total fixed capital formation, value
IPV	Private total fixed capital formation, volume
IPV1	Private total fixed capital formation in agriculture, volume
IPV2	Private total fixed capital formation in industry, volume
IPV3	Private total fixed capital formation in services, volume
ISKV	Increase in stocks, volume
IT	Gross total fixed capital formation, value
ITV	Gross total fixed capital formation, volume
LF	Labor force
LFPR	Labor force participation rate
LLRPCP	Domestic expenditure excl. government wages, deflator, log
NIT	Net indirect taxes, value
NITV	Net indirect taxes, volume
NLG	Government net lending, value
NLGQ	Government net lending, as a percentage of GDP

NPROD3	Labor productivity in services relative to the total economy
PCG	Government final consumption expenditure, deflator
PCGNW	Government final non-wage consumption expenditure, deflator
PCGW	Government final wage consumption expenditure, deflator
PCP	Private final consumption expenditure, deflator
PDTY	Labor productivity of the total economy
PFDD	Final domestic expenditure, deflator
PGDP	Gross domestic product, market prices, deflator
PGDPB	Gross domestic product, business sector, deflator
PIT	Gross total fixed capital formation, deflator
PROD	Labor productivity of the business economy
PROD1	Labor productivity in agriculture
PROD2	Labor productivity in industry
PROD3	Labor productivity in services
PROF	Profits and other non-wage income, value
PTDD	Total domestic expenditure, deflator
PTE	Total expenditure excl. government wage consumption, deflator
RPROD2	Labor productivity ratio between industry and services
RWAGQ2	Wage quota in industry relative to services
RWSSE2	Compensation rate in industry relative to agriculture and services
SAVG	Government saving, value
SAVH	Household saving, value
SHEE1	Share of agriculture in all business sector employees
SHEE2	Share of industry in all business sector employees
SHEE3	Share of services in all business sector employees
SHETX2	Share of industry in total non-agricultural business employment
SHET2	Share of industry in total business employment
SHET3	Share of services in total business employment
SHGVAV1	Share of agriculture in business gross value added, volume
SHGVAV2	Share of industry in business gross value added, volume
SHGVAV3	Share of services in business gross value added, volume
SHIPV2	Share of industry in private total fixed capital formation, volume
SHIPV3	Share of services in private total fixed capital formation, volume
SHIPV1	Share of agriculture in private total fixed capital formation, volume
SRATIO	Household saving ratio
SSPG	Social security benefits paid by government
TDD	Total domestic expenditure, value
TDDV	Total domestic expenditure, volume
TROPH	Non-social security transfers paid by households, value
TRPESH	Employees & self-employed contributions to social security, value
TRPGSH	Government employers contributions to social security, value
TRPH	Total transfers paid by households, value
TRRH	Current transfers received by households, value
TRSSH	Social security contributions by households, value
TY	Total direct taxes, value
TYB	Direct taxes on business, value
TYH	Direct taxes on households, value
UCC	User costs of capital
ULCB	Unit labor costs in the business sector
UN	Unemployment
UNR	Unemployment rate
WAGE	Wages, value
WAGEG	Wages of the government sector, value
WRG	Compensation rate of government employees

WSSE	Compensation rate of the business sector
WSSE1	Compensation rate in agriculture
WSSE2	Compensation rate in industry
WSSE3	Compensation rate in services
WSSS	Compensation of employees, value
XGSV	Exports, volume
YDH	Household disposable income, value
YDRH	Household disposable income, real
YOTH	Self-employment & property income received by households, value
YPE	Property income received by households, value
YPG	Government current disbursements, value
YPGT	Government total disbursements, value
YPGTQ	Government total disbursements, as a percentage of GDP
YPH	Current disbursements of households, value
YRG	Government current receipts, value
YRGQ	Government current receipts, as a percentage of GDP
YRH	Current receipts of households, value
YSE	Self-employment income received by households, value

A II.3: TFP sub-model variables

Variable name	Variable description	Variable status	Geographic aggregation
CEMP	Weights, calculated by county employment shares	Exogenous	County
CSFTFP	Total factor productivity, CSF policy effects included	Endogenous	National
CTFPGR	County TFP growth	Endogenous	County
DNTFPGR	Change of national TFP growth due to CSF policy	Endogenous	National
DUM99	Dummy variable: year 1999	Exogenous	County
BPDUM	Dummy variable: Budapest	Exogenous	County
HUMRES	Human resources expenditures (education, training and R&D)	Exogenous	County
INFRA	Investment in physical infrastructure	Exogenous	County
KIMP	Imported technologies	Exogenous	County
KNAT	Domestically available technological knowledge	Exogenous	National
RD	Private and public R&D expenditures	Exogenous	County
TFP	Total factor productivity	Endogenous	National

Appendix 3: The equation system of the SCGE sub-model[28]

The output by the Cobb-Douglas production function[29]:

(1) $$y_{i,m,t} = A_{i,m,t}\left(L_{i,t}\right)L_{i,m,0}^{a_{i,m}}K_{i,m,0}^{1-a_{i,m}}$$

where in case of starting point $t = 0$ come true:

(1-a) $$L_{i,0} = \sum_{m=1}^{M} L_{i,m,0}$$

Since $a_{i,m} = a_{j,m}$ in case of $\forall$ *i,j* and *m,* it follows that we can leave out the *i* index of $a_{i,m}$ from the (1) equation:

(1-b) $$y_{i,m,t} = A_{i,m,t}\left(L_{i,t}\right)L_{i,m,0}^{a_m}K_{i,m,0}^{1-a_m}$$

(2) $$A_{i,m,t}\left(L_{i,t}\right) = \zeta_{i,m,t}A'_{i,m}\ L_{i,t}^{\gamma_m}$$

where $\zeta_{i,m,t}$ is a flavour factor for the given *TFP* is defined as follows[30]:

(2-a) $$\zeta_{i,m,t} = TFPSHARE_{i,m}\left(1+TFPGROWTH\right)^{t}\left(1+TFPSHOCK_{i,m,t}\right)$$

furthermore $A'_{i,m} = A'_{j,n}$ and $\gamma_m = \gamma_n$ in case of $\forall$ *i,j,m,n* so we can leave these indexes:

(2-b) $$A_{i,m,t}\left(L_{i,t}\right) = \zeta_{i,m,t}A'\ L_{i,t}^{\gamma}$$

The F.O.B. prices[31] of region *i* in sector *m*

(3) $$q_{i,m,t} = \frac{w_{i,t}^{a_m}r^{1-a_m}}{A_{i,m,t}a_m^{a_m}\left(1-a_m\right)^{1-a_m}}$$

The input factor demand functions[32]:

(4) $$L'_{i,m,t} = \frac{a_m}{w_{i,t}}q_{i,m,t}y'_{i,m,t}$$

[28] On the basis of Koike and Thissen (2005) compiled by Péter Járosi.
[29] See the formula of cell equilibrium!DB18
[30] See the formulas of cells equilibrium!D166 and D167
[31] F.O.B. = „free on board”, See the formula of cell equilibrium!DB13
[32] See the formulas of cells equilibrium!DB270 and DB271

(5) $$K'_{i,m,t} = \frac{1-a_m}{r} q_{i,m,t} y'_{i,m,t}$$

The utility functions of the households[33]:

(6) $$u_{i,t} = \alpha \ln[h_i] + \sum_{m=1}^{M} \beta_m \ln[(1-\sigma_1)x_{i,m,t}]$$

The budget constraints of the households:

(7) $$l_i\, w_{i,t} + \frac{r\mathbf{K}_t}{\mathbf{N}_t} = \sum_{m=1}^{M} p_{i,m,t} x_{i,m,t}$$

We can derive the following demand functions[34]:

(8) $$x_{i,m,t} = \frac{\beta_m}{1-\alpha} \frac{1}{p_{i,m,t}} \left(l_i\, w_{i,t} + \frac{r\mathbf{K}_t}{\mathbf{N}_t} \right)$$

The probability of buying good *m* in region *i* when living in region *j* is defined as follows[35] in case of *m*=1 and *m*=2:

(9) $$s_{ij,m,t} = \frac{y_{i,m,t} e^{-\lambda_m q_{i,m,t}\left(1+\tau_{ij,m}\right)}}{\sum_{k=1}^{I} y_{k,m,t} e^{-\lambda_m q_{k,m,t}\left(1+\tau_{kj,m}\right)}}$$

in case of *m*=3 and *m*=4:

(10) $s_{ij,m,t} = 1$ if $i = j$, or rather $s_{ij,m,t} = 0$ if $i \neq j$

The interregional trade volume:

(11) $$z_{ij,m,t} = N_{j,t} x_{j,m,t} s_{ij,m,t}$$

The cost of transportation is also included in the C.I.F. price:

(12) $$p_{j,m,t} = \sum_{i=1}^{I} s_{ij,m,t} q_{i,m,t} \left(1+\tau_{ij,m}\right)$$

The market equilibrium conditions:

- labor market:

(13) $\sum_{m=1}^{M} L'_{i,m,t} = L_{i,t}$ in every region, $\forall\ i = 1..I$

[33] See the formula of cell equilibrium!D207
[34] See the formula of cell equilibrium!DB168
[35] See the formula of cell equilibrium!DB68

- capital market:

(14) $$r\left(\sum_{i=1}^{I}\sum_{m=1}^{M}K'_{i,m,t}-\mathbf{K}_t\right)=0$$

- goods market (demand)[36]:

(15) $$N_{j,t}x_{j,m,t}=\sum_{i=1}^{I}z_{ij,m,t}$$

- goods market (supply):

(16) $$y'_{j,m,t}=\sum_{i=1}^{I}(1+\tau_{ij,m})z_{ij,m,t}$$

The labor migration model[37]:

(17) $$L_{i,t+1}=\left(L_{i,t}-\phi\frac{\sum_{i\in I}L_{i,t}}{I}+\frac{e^{\theta(u_{i,t}+c_i)}}{\sum_{i\in I}e^{\theta(u_{i,t}+c_i)}}\phi\sum_{i\in I}L_{i,t}\right)G$$

where i=1..I the index of regions, t=0..T the index of year, consequently $L_{i,t}$ means the labor of region i int he year t. To take into consideration $\sum_{i\in I}L_{i,t}=\mathbf{L}_t$, and to perform the parentheses:

(17-a) $$L_{i,t+1}=\left\{L_{i,t}+\left(\frac{e^{\theta(u_{i,t}+c_i)}}{\sum_{i\in I}e^{\theta(u_{i,t}+c_i)}}-\frac{1}{I}\right)\phi\mathbf{L}_t\right\}G$$

The (17-a) equations well exemplifies, that if value of $e^{\theta(u_{i,t}+c_i)}$ in the given region is exactly the average of the $e^{\theta(u_{i,t}+c_i)}$ value of the all regions:

(17-b) $$e^{\theta(u_{i,t}+c_i)}=\frac{\sum_{i\in I}e^{\theta(u_{i,t}+c_i)}}{I}$$

So if the utility function gives the value of $u_{i,t}$ according to (17-b) equation, then there is no migration in the given region. In case of t=0 this condition is true in each regions. To replace (17-b) into (17-a):

(17-c) $$L_{i,t+1}=L_{i,t}G$$

Simply equation is true in each region according to (17-b).

[36] Equation (15) automatically follows from equations (9), (10) and (11).
[37] This equation is executed by the „longrun” subroutine.

To use notation σ_m as the share of investment in sector m, and $\iota_{i,m,t}$: investment goods:

(18) $$\iota_{i,m,t} = \sigma_m N_{i,t} x_{i,m,t}$$

So the (1- σ_m) part of outputs are consumed in the households, accordingly the equation (6) is explainable.

(19) $$u_{i,t} = \alpha \ln[h_i] + \sum_{m=1}^{M} \beta_m \ln[(1-\sigma_m) x_{i,m,t}]$$

The investment increases total capital as follows:

(20) $$\mathbf{K}_{t+1} = (1-\delta)\mathbf{K}_t + \sum_{i=1}^{I}\sum_{m=1}^{M} \iota_{i,m,t}$$

Where δ is the average depreciation rate.

Appendix 4: Variable sources – Macro sub-model[38]

1. Raw Variables

Variable Description	Name	Source variables	Database
Government consumption of fixed capital, value	CFKG	S13_B.2g (RES); HUN.1.0.0.0.UKCG	S-Statistic; AMECO
Government final consumption expenditure, value	CG	HUN.1.0.0.0.UCTG	AMECO
Government final wage consumption expenditure, value	CGW	HUN.1.0.0.0.UWCG	AMECO
Private final consumption expenditure, value	CP	HUN.1.0.0.0.UCPH	AMECO
Private final consumption expenditure, volume	CPV	HUN.1.1.0.0.OCPH	AMECO
Employees in agriculture	EE1	HUN.1.0.0.0.NWT1	AMECO
Employees in industry	EE2	HUN.1.0.0.0.NWT2 +HUN.1.0.0.0.NWT4	AMECO
Employees in services	EE3	HUN.1.0.0.0.NWT5	AMECO
Government employment	EG	Imputed	/
Self-employed	ES	HUN.1.0.0.0.NSTD	AMECO
Total employment	ET	HUN.1.0.0.0.NETN	AMECO
Employment in agriculture	ET1	HUN.1.0.0.0.NET1	AMECO
Employment in industry	ET2	HUN.1.0.0.0.NET2 +HUN.1.0.0.0.NET4	AMECO
Employment in services	ET3	HUN.1.0.0.0.NET5	AMECO
Gross domestic product in the EU15, volume, Euro	EUGDP	E15.1.0.0.0.UVGD	AMECO
Foreign gross domestic product, business sector, volume, factor cost	FGDPBV	Imputed	/
FISIM, volume	FISIMV	HUN.1.1.0.0.OVG0 -HUN.1.0.0.0.OVGE	AMECO
Gross domestic product, value, market prices	GDP	HUN.1.0.0.0.UVGD	AMECO
Gross domestic product, volume, market prices	GDPV	HUN.1.1.0.0.OVGD	AMECO
Gross value added in agriculture, volume	GVAV1	HUN.1.1.0.0.OVG1	AMECO
Gross value added in industry, volume	GVAV2	HUN.1.1.0.0.OVG2 +HUN.1.1.0.0.OVG4	AMECO
Gross value added in services, volume	GVAV3	HUN.1.1.0.0.OVG5	AMECO
Government fixed capital formation, value	IG	HUN.1.0.0.0.UIGG	AMECO
Private total fixed capital formation in industry, value	IP2		
Private total fixed capital formation in services, value	IP3		
Long term interest rate on government bonds	IRL	HUN.1.1.0.0.ILN	AMECO
Increase in stocks, value	ISK	HUN.1.0.0.0.UIST	AMECO
Gross total fixed capital formation, value	IT	HUN.1.0.0.0.UIGT	AMECO
Gross total fixed capital formation, volume	ITV	HUN.1.1.0.0.OIGT	AMECO
Net government capital transfers received	KTRRG	HUN.1.0.0.0.UKTTG - HUN.1.0.0.0.UKTGT	AMECO
Labor force	LF	HUN.1.0.0.0.NLTN	AMECO
Net indirect taxes, value	NIT	HUN.1.0.0.0.UTVN	AMECO
Government final consumption expenditure, deflator	PCG	HUN.3.1.0.0.PCTG	AMECO

[38] Compiled by Onno Hoffmeister

Working-age population	POPT	HUN.1.0.0.0.NPAN	AMECO
Social security benefits paid by government	SSPG	S.14_D.62 (RES)	S-Statistic
Time (year-1995)	TIME	-2; -1; 0; 1; 2; ...; 18	/
Indirect taxes, value	TIND	HUN.1.0.0.0.UTVT	AMECO
Total direct taxes, value	TY	S1_D.5(RES)	S-Statistic
Direct taxes on households, value	TYH	S14_D.5 (USES)	S-Statistic
Transport costs	TPCOST	Transman Kft.	
Non-social security transfers paid by households, value	TROPH	S14_D.7(USES) + S15_D.7(USES)	S-Statistic
Private employers social security contributions	TRPBTH	S1_D.12(RES) - S13_D12(USES)	S-Statistic
Employees & self-employed contributions to social security, value	TRPESH	S14_D.61(USES) -S1_D.12(RES)	S-Statistic
Other current transfers paid by government	TRPG	S13_D.7 (USES)	S-Statistic
Government employers contributions to social security, value	TRPGSH	S13_D12(USES)	S-Statistic
Other current transfers received by government, value	TRRG	S13_D7(RES)	S-Statistic
Compensation of employees, value	WSSS	HUN.1.0.0.0.UWCD	AMECO
Compensation of employees in agriculture	WSS1	HUN.1.1.0.0.UWC1	AMECO
Compensation of employees in industry	WSS2	HUN.1.1.0.0.UWC2 +HUN.1.1.0.0.UWC4	AMECO
Compensation of employees in services	WSS3	HUN.1.1.0.0.UWC5	AMECO
Exports, volume	XGSV	HUN.1.1.0.0.OXGS	AMECO
Exchange rate to the Euro	XR	HUN.1.0.99.0.XNE	AMECO
Coefficient	XTAU	0.67	
Property income received by households, value	YPE	S 14_D.4(RES) -S14_D.4(USES) +S15_D.4(RES) -S15_D.4(USES)	S-Statistic
Property income paid by government, value	YPEPG	HUN.1.0.0.0.UYIG	AMECO
Property income received by government, value	YPERG	S13_D.4(RES)	S-Statistic
Self-employment income received by households, value	YSE	S14_B.2g(RES) + S15_B.2g(RES) + S15_B.3g(RES)	S-Statistic
Non-social security transfers received by households	ZCS001	S14_D.7 (RES) + S15_D.7 (RES)	S-Statistic

2. Generated Variables

Variable Description	**Name**	**Source variables**
Government final non-wage consumption expenditure, value	CGNW	CG-CGW
Self-employment share in business economy	ESQ	ES/ETB
Employment of the business sector	ETB	ET-EG
Gross domestic product in the EU15, volume	EUGDPV	EUGDP*XR/PGDP
Gross domestic product of the business sector, value, factor costs	GDPB	GDP-GDPG
Gross domestic product, business sector, volume, factor cost	GDPBV	GDPV-GDPGV

Gross domestic product of the government sector, value	GDPG	CGW+TIND-TSUB+CFKG
Gross domestic product of the government sector, volume	GDPGV	EG*CGW(1995)/EG(1995) +CFKG*IT/ITV +GDPV/ET(1995)/GDPV(1995) -EG*CGW(1995)/ET(1995) /EG(1995)/GDPV(1995)
Private total fixed capital formation, volume	IPV	ITV-IG/PIT
Private total fixed capital formation in industry, volume	IPV2	IP2/PIT
Private total fixed capital formation in services, volume	IPV3	IP3/PIT
Government final non-wage consumption expenditure, deflator	PCGNW	CGNW/(CG/PCG-CGW/PCGW)
Government final wage consumption expenditure, deflator	PCGW	WRG/WRG(1995)
Ratio of government final consumption expenditure deflator to GDP deflator	PCGQ	PCG/PGDPB
Private final consumption expenditure, deflator	PCP	CP/CPV
Gross domestic product, business sector, deflator	PGDPB	GDPB/GDPBV
Gross total fixed capital formation, deflator	PIT	IT/ITV
Labor productivity in agriculture	PROD1	GVAV1/ET1
Profits and other non-wage income, value	PROF	GDP-WSSS-YSE-NIT
Labor productivity ratio between industry and services	RPROD2	GVAV2/ET2*ET3/GVAV3
Share of industry in all business sector employees	SHEE2	EE2/(ET-ES-EG)
Share of services in all business sector employees	SHEE3	EE3/(ET-ES-EG)
Share of agriculture in total business employment	SHET1	ET1/ETB
Share of industry in total non-agricultural business employment	SHETX2	ET2/(ET2+ET3)
Share of industry in private total fixed capital formation, volume	SHIPV2	IPV2/IPV
Share of services in private total fixed capital formation, volume	SHIPV3	IPV3/IPV
Total tax ratio of indirect taxes	TINDQ	TIND/FDD
Share of non-social security transfers, paid by households, in their income	TROPHQ	TROPH/YRH
Share of private employers' contribution to social security and pension fonds in private sector wages	TRPBTHQ	TRPBTH/(WAGE-WAGEG)
Share of employees & self-empl. social security contributions in market income	TRPESHQ	TRPESH/(WAGE-WAGEG+YSE)
Share of government employers social security contributions in public sector wages	TRPGSHQ	TRPGSH/WAGEG
Subsidies	TSUB	TIND-NIT
Share of subsidies in GDP	TSUBQ	TSUB/GDP
Direct taxes on business, value	TYB	TY-TYH
Total tax ratio of direct taxes on profits	TYBQ	TYB/PROF
Total tax ratio of direct taxes on households	TYHQ	TYH/YRH
Compensation rate of government employees	WRG	CGW/EG
Compensation rate of government employees relative to total economy	WRGQ	CGW/EG/WSSE

Compensation rate of the business sector	WSSE	(WSSS-CGW)/(ETB-EG-ES)
Compensation rate in agriculture	WSSE1	WSS1/EE1
Compensation rate in industry	WSSE2	WSS2/EE2
Compensation rate in services	WSSE3	WSS3/EE3
Coefficient	XNITV	(TIND(1995)-TSUB(1995)) /(GDP(1995)-CGW(1995))
Coefficient	XPDTY	1/GDPV(1995)/ET(1995)
Share of property income in profits	YPEQ	YPE/PROF
Share of income from self-employment in total income	YSEQ	YSE/(ES*WSSE)

Appendix 4: Transportation cost calculation[39]

The transport infrastructure and the transport connections have a decisive role in the operation of national economy and in the provision of the interregional connections.
The calculation and accounting of the interregional accessibilities can be made on the basis of "general transport costs (impedances)" characteristic for good transport:

$TC_{ij} = x \cdot$road transport costs + $y \cdot$rail transport costs

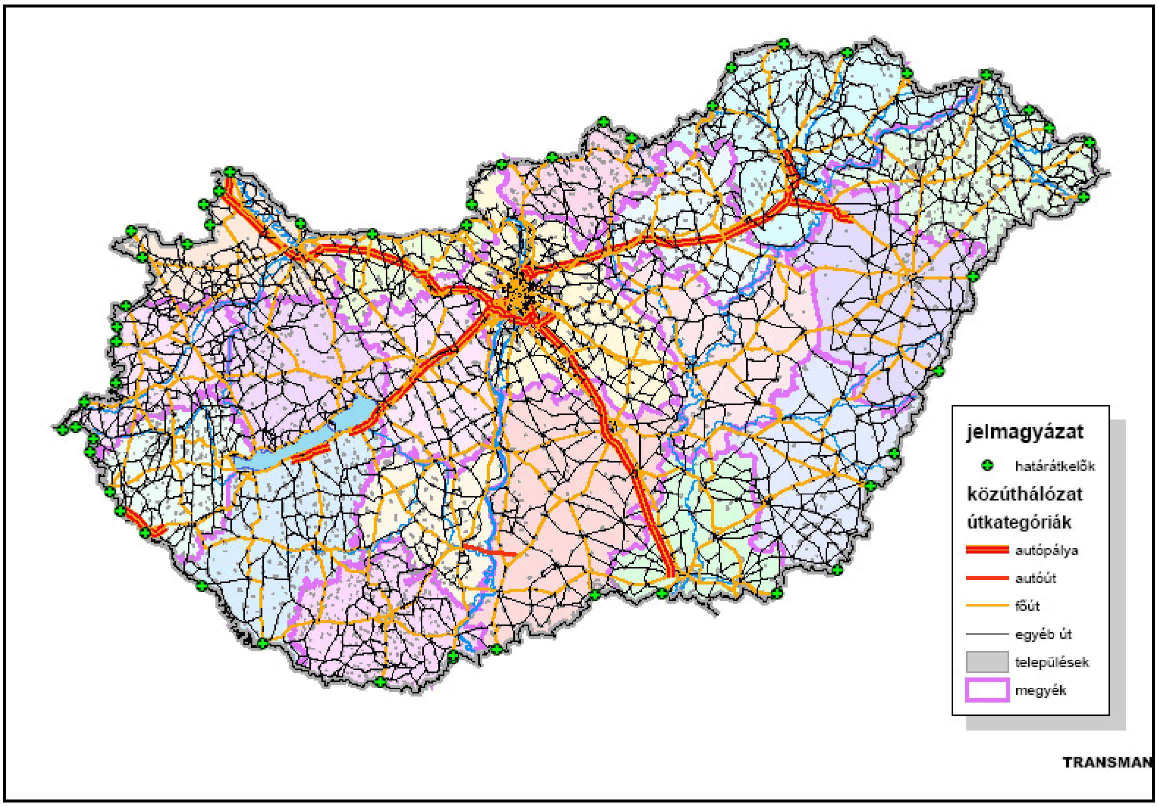
$$\mathrm{TC}_{ij} = x \cdot (a_1 \cdot \mathrm{HC}_{ij} + b_1 \cdot \mathrm{HT}_{ij}) + y \cdot (a_2 \cdot \mathrm{RC}_{ij} + b_2 \cdot \mathrm{RT}_{ij})$$

The transport costs consist of road and rail transport costs (HC, RC) and time (HT, RT) among counties. These costs should be expressed in generalized, monetary terms (HUF) of which an average is derived (x+y=1) (the transport time could be omitted, $b_1=b_2=0$).
The coefficients (a, b) and the weighting factors (x, y) were determined by expert estimations, since there is no way in this framework to conduct surveys.
The time and cost values among regions (counties) are calculated by deriving an average of route impedances provided by road and rail traffic model. These models calculate impedances at each county pairs for several node pairs (p, q) along the length (L_{pq}) of the possible routes (R_{pq}), which is a set of individual links (s), by considering the road and rail line characteristics (k) according to the followings (see the figures as well):

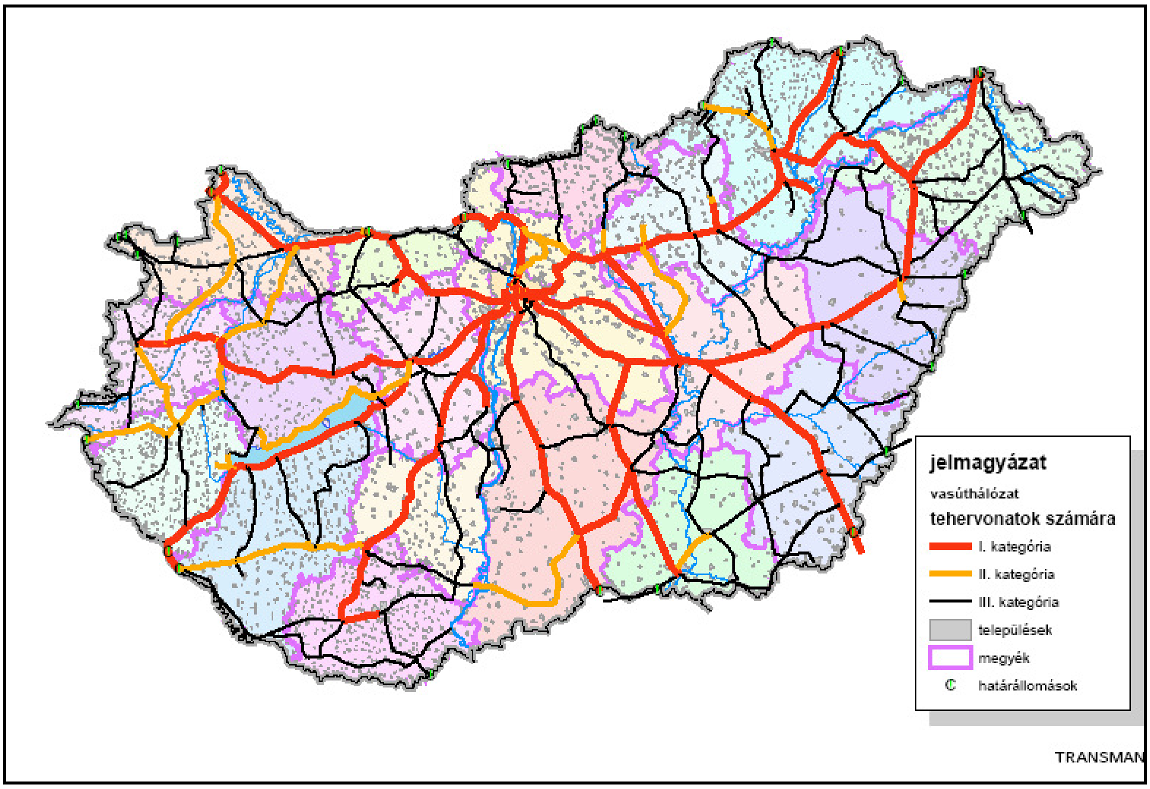
$$L_{pq,k} = \sum_{s \in R_{pq}} l_{s,k}$$; average distance between counties: $$L_{ij,k} = \frac{1}{n} \sum_p \sum_q L_{pq,k}$$

The transport costs among counties are supplied in a matrix having 20x20 cells for the 'present' and the dates (t - year) according to the operation horizon (2010 and 2020) of the models, supplemented with a set of matrices containing values for cells among border sections and counties.
The cost matrices *($TC_{ij,v,t}$)* can be calculated for several scenarios taking into account the key infrastructure elements (motorway, highway and rail line investments) according to the governmental plans. These matrices are inputs to the economic model parts.

[39] Written by János Monigl and Zoltán Újhelyi



1. Figure Hungarian road network model



2. Figure Hungarian rail network model

Calculation of generalised transport costs: (forwarding costs+time costs)

in road transport: (the explanations of the formulas see in **Table 1**) for industrial goods: $GIVH_{ij} = FIVH_{ij} \cdot (DH_{ij} \cdot CIVH + TH_{ij} \cdot KIVH)$ [EUR]

for agricultural goods: $GAVH_{ij} = FAVH_{ij} \cdot (DH_{ij} \cdot CAVH + TH_{ij} \cdot KAVH)$ [EUR]

DH = distance on road; TH = transport time on road

in rail transport:

for industrial goods $GIVR_{ij} = FIVR_{ij} \cdot (DR_{ij} \cdot CIVR + TR_{ij} \cdot KIVR)$ [EUR]

for agricultural goods: $GAVR_{ij} = FAVR_{ij} \cdot (DR_{ij} \cdot CAVR + TR_{ij} \cdot KAVR)$ [EUR]

DR = distance on rail; TR = transport time on rail

in transport general

for industrial goods $GIV_{ij} = a*GIVH_{ij} + b*GIVR_{ij}$ [EUR]
where: a+b=1.0; a=0.74 and b=0.26 proportion by KSH data*
for agricultural goods: $GAV_{ij} = c*GAVH_{ij} + d*GAVR_{ij}$ [EUR]
where c+d=1.0; c=0.67 and d=0.33 proportion by KSH data*[40]

Transported good values

for industrial goods value: $FIV_{ij} = (FIVH_{ij} + FIVR_{ij})$ [kEUR]

for agricultural goods value: $FAV_{ij} = (FAVH_{ij} + FAVR_{ij})$ [kEUR]

Transport cost ratios: (generalised transport costs/good value):
the generalised cost ratio for industrial goods: $RIV_{ij} = GIV_{ij}/FIV_{ij}$ [-]

the generalised cost ratio for agricultural goods: $RAV_{ij} = GAV_{ij}/FAV_{ij}$ [-]

Input data		Industry(I)	Agriculture(A)	Comments	Volumes	Dimension
Flows (F) in tons	on road (H)	FITH	FATH	from ETIS	291 896 440	[tons]
in tons	on rail (R)	FITR	FATR	ETIS	24 682 299	[tons]
Flows (F) in kEUR	on road	FIVR	FAVH	ETIS*	48 43 288	[kEUR]
	on rail	FIVR	FAUR	ETIS*	866 032	[kEUR]
Unit forwarding costs (C)/ton · km	on road	CITH	CATH	fom TNO	0.06	[EUR/ton km]
	on rail	CITR	CATR	TNO	0.03	[EUR/ton km]
Unit forwarding costs (C)/ kEUR ·	on road	CIVH	CAVH	TRANSMAN*	3,6**	[EUR/kEUR·km]
	on rail	CIVR	CAVR	TRANSMAN*	0,72 **	[EUR/kEUR·km]
Unit time costs (K)/ton · hour	on road	KITH	KATH	fom TNO	3	[EUR/ton · hour]
	on rail	KITR	KATR	TNO	1	[EUR/ton · hour]
Unit time cost EUR/kEUR · hour	on road	KIVH	KAVH	TRANSMAN*	180,00 **	[EUR/kEUR· hour]
	on rail	KIVR	KAVR	TRANSMAN*	27,00 **	[EUR/kEUR· hour]

*after transformation of ETIS and TNO data
**at the HU forwarding cost 67% and the time cost 33% of the NL levels had been considered

1.Table Transport cost calculation for SCGE (Hungary)

Differentiation of average unit costs

The real transport fees are degressive by distance and time. To avoid getting over-proportional cost on the longer distance and time a modification had been made.

[40] * Yearbook of Hungarian Central Statistical Office (KSH) 2003, Section 26. Transport

For the calculation of degressive transport fees we took into consideration a factor (f) to modify the average unit transport fees, which was calculated as follows:

$$f_1 = e^{-\alpha(X-50)}$$

Where:

X: distance in km on road (DH) and on rail (DR)

α constant parameter is 0.0015

The formula and figure says that it had been assumed the average unit cost is until 50 km, further there is a decrease, which results degressive total transportation cost ratio by distance. For the time cost calculation we also used a similar equation:

$$f_2 = e^{-\beta(Y-1)}$$

Where:

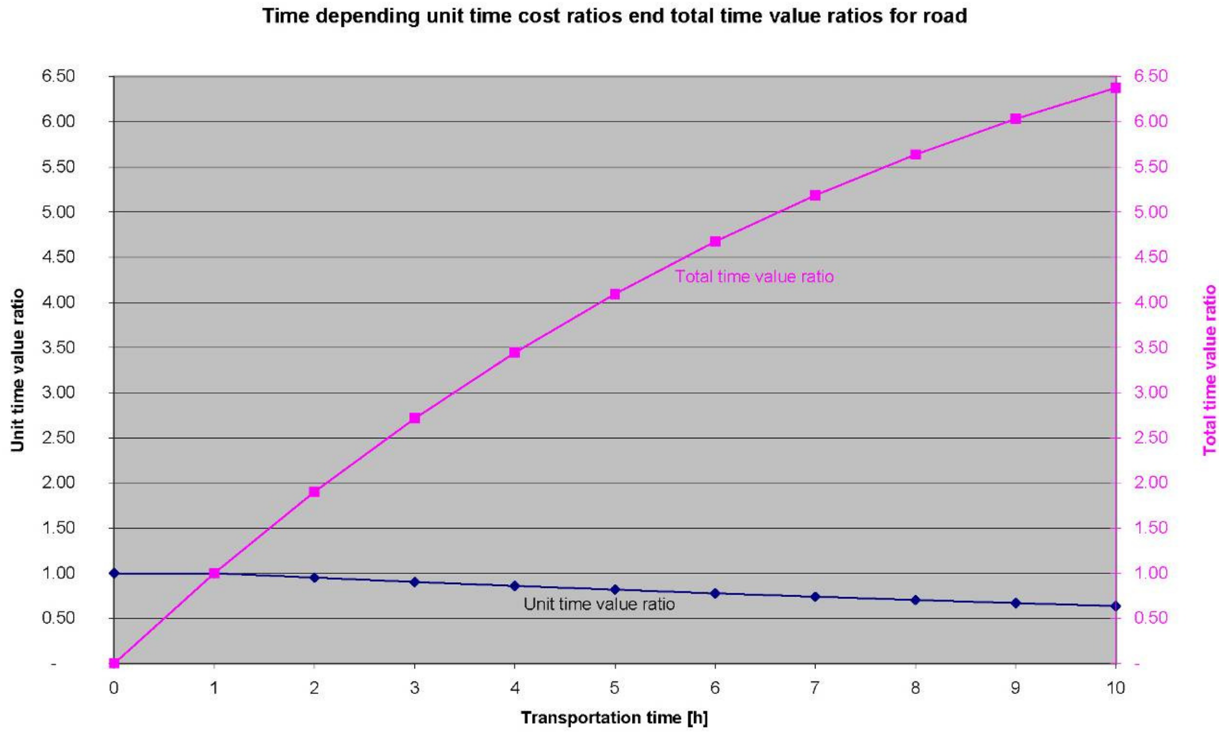
Y: is the time in hours on road (TH) and on rail (TR)

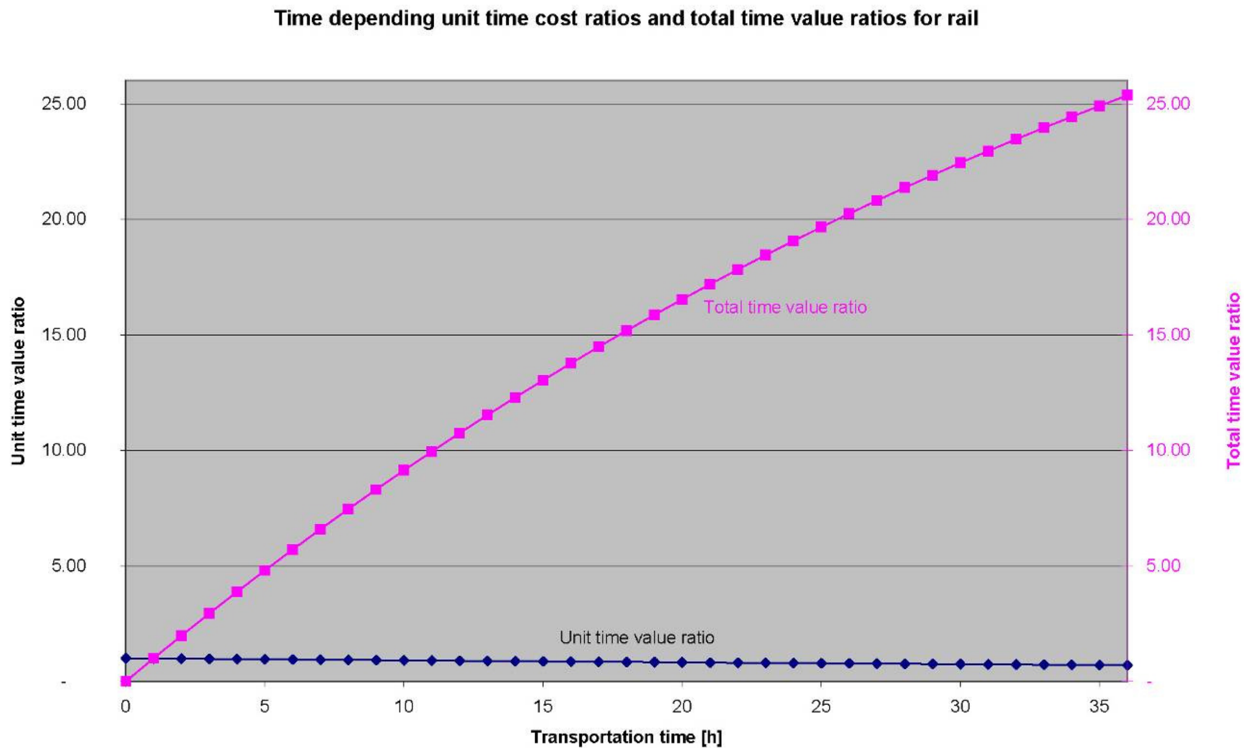
β: constant parameter

0.05 for road time cost and

0.01 for rail time cost

The average unit forwarding cost and time cost (see **Table 1)** had been multiplied by the factors $\mathbf{f_1}$ and $\mathbf{f_2}$ at the calculation of the distance and time depending transportation costs.





The results of the calculations for industrial and agricultural goods by rail and road transport as well for the whole transport can be seen in the attached Tables 2-9.
The last two Tables 10 and 11 contain the transport cost/transported good flow values ratios are input data for the SGE model.
In this results there are included beside times also "technological times" on the road +2hours and on the rail +24 hours. That is the explanation, that the ratios are relatively high.
Therefore calculations had been done also without these technological times, the results can be seen in Tables 12 and 13, the ratios are substantially lower then in the previous case.
The changes of the accessibilities because of developments of the road and rail infrastructure in the future will influence also the transportation costs and further the results of the economy models.

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	10688010	4464318	7239560	8120312	14931082	9134878	6295654	7224648	8327320	4628160	4196960	2378337	7043540	3076692	8191818	4034463	2273208	4562129	8534862	4338148
2	Baranya	5559757	4432228	1733947	2403367	810403	2391626	1803458	3504763	467817	389461	1824135	209346	1590150	8274465	452116	308409	5748764	1654002	1556079	1234199
3	Bács-Kiskun	7625237	1533923	5034451	9755988	1226683	7465145	992906	1355587	2911954	484983	1053405	307760	1671754	1678536	3080771	1224520	768426	741522	1159548	654872
4	Békés	8695110	2126380	9776281	2180555	778657	5455898	1319927	1192216	1090580	380800	1032833	233587	2150904	1867380	1563997	730206	1319855	641683	1168860	605199
5	Borsod-AbaŁj-Zem	14854482	695056	1185562	752113	9316337	1106374	1138695	2355438	3943589	8835883	804114	7309006	4008346	543219	2881589	3849068	442063	1289633	979105	1250124
6	Csongrád	9764918	2115003	7471347	5456933	1144115	3460921	1336183	1416652	2305579	497641	1184048	310395	2311501	2009375	2539803	1137629	1243563	735661	1288365	682029
7	Fejér	6283527	1526652	1006055	1328926	1144400	1357373	5768828	3444189	497624	464101	6834997	241800	1987636	761115	476947	284454	597363	2205940	7288136	2013766
8	Győr-Moson-Sopron	7668731	3864435	1579470	1383709	2432946	1650812	4138236	6877739	1761835	1138346	2161218	584254	2306618	2451584	1603980	1208901	2261395	5742518	2294429	9449208
9	Hajdú-Bihar	8189103	571631	2819424	1055866	4520289	2232220	803945	1269488	4834091	2804252	581717	2053513	2123507	476993	7354577	9611099	371275	687872	682996	665452
10	Heves	4570868	336649	469877	368270	8846577	480947	456690	1097053	2506910	3113010	309597	2886356	1028629	253058	2656281	1400673	198842	632937	437696	607196
11	Komárom-Esztergom	4198298	1551326	1065030	1037068	808048	1196874	6823882	1785456	360937	315026	1868471	149362	1308013	957075	342431	209099	780044	1614900	7853527	1692995
12	Nógrád	2355289	180983	298985	225848	7323033	300314	240203	566495	1836013	2890659	147749	643259	588242	134356	1775231	1142701	107036	332697	231380	323334
13	Pest	7056800	1275833	1582974	2025314	4052919	2177873	1991321	2175148	2160075	1042332	1309489	595134	2219940	929518	2205813	772610	663756	1323969	2566753	1269103
14	Somogy	3834264	8266322	1894993	2103107	626104	2268778	898469	2221586	389621	292970	1116999	155201	1152032	3567458	361726	250433	5059500	957609	704056	519267
15	Szabolcs-Szatmár-Bereg	8059405	550287	2981416	1514161	3223899	2458951	769616	1156235	7354442	2967256	552766	1979047	2170607	442372	4375147	12904132	362890	620163	626468	603021
16	Jász-Nagykun-Szolnok	3988647	377614	1187869	707041	4306932	1101666	463481	875526	9610553	1566683	339420	1278363	761243	310649	12904147	3262402	220717	490234	444043	469120
17	Tolna	2836200	5748659	868395	1485396	518535	1405753	705517	2051120	304373	231114	919994	124125	828272	5075529	300158	179650	2216597	1105593	830742	861839
18	Vas	4842499	1824219	866208	743349	1332719	859114	2656069	5743028	953972	656447	1945850	344377	1404716	1056355	860210	677267	1219446	1489773	1106392	2712960
19	Veszprém	8548361	1316991	1178060	1177722	980672	1304105	7298038	1905654	421659	441479	7862721	232453	2564113	596828	387055	272271	703233	918963	2804055	719531
20	Zala	4595406	1356991	763593	704299	1290936	794266	2426154	9450225	921764	629199	2038666	334447	1342110	572663	836206	645221	946307	2713317	866447	1406110
Sum		134 214 912	44 115 501	51 003 498	44 529 342	69 615 285	48 603 888	48 327 272	57 668 248	52 960 707	33 769 801	38 085 147	22 350 121	40 561 871	35 035 219	55 150 005	44 105 209	27 504 281	30 461 115	43 423 940	32 077 473

2. Table Forwarding costs for industrial goods on road [Euro] (GIVH forwarding cost part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	57906650	3260723	6466318	5910271	10595908	6624512	7625198	5489839	5672512	4615927	5553168	2478769	17926750	2289639	5272942	3734820	1929891	3239145	7136841	3132746
2	Baranya	4066206	8106689	1545796	1646145	521837	1732961	1441129	2483411	311977	261083	1282730	141832	1138429	8486008	298511	212302	6765217	1176912	1211433	979466
3	Bács-Kiskun	6859510	1369013	7753796	8137504	838801	8207087	926953	931887	2092512	382760	812372	225387	1714600	1305035	2106506	1187233	838914	513470	885088	465844
4	Békés	6262570	1454312	8131690	3741929	564337	5837853	933637	776542	1042699	289365	712275	168122	1629854	1255054	1194358	777993	930724	429378	800797	407513
5	Borsod-AbaŁj-Zem	10414432	451212	811759	546116	16877980	757232	750104	1503825	3630473	10681844	545220	6801331	2886092	340979	2970500	3144285	289869	830287	628480	806268
6	Csongrád	7068119	1531611	8214722	5836800	782517	5975358	1029802	916853	1721119	373020	825737	217445	1856092	1388130	1778601	1077052	976059	502509	920873	460655
7	Fejér	7598177	1220874	937830	935705	747992	1036580	10251737	2920705	326618	348515	8597476	189266	2183939	793047	302676	220838	663145	1707950	9044738	1628065
8	Győr-Moson-Sopron	5770128	2737604	1088169	904056	1551112	1061218	3522008	11043598	1132341	759754	2235089	411348	1694145	1893739	1029241	813691	1664102	6635467	2314196	8022194
9	Hajdú-Bihar	5597540	381569	2025958	1009624	4060589	1666840	531326	818848	8646211	2355700	388866	1500866	1506712	304959	8971989	9260583	250165	448788	441142	434882
10	Heves	4509282	225361	369905	279818	10676709	360706	348359	734614	2105125	5100470	251895	3265921	1160018	166234	2017566	1460183	139888	416702	302461	403487
11	Komárom-Esztergom	5499850	1084723	815355	711168	543093	814031	8606378	1851237	237999	251793	5054686	131424	1551367	733379	220152	163556	624408	1243833	7592151	1267900
12	Nógrád	2432536	122638	217311	162584	6803595	209581	188668	396310	1340800	3264771	131176	1400720	649237	89731	1235411	939571	76236	224960	163388	217641
13	Pest	17930741	913187	1617794	1537770	2925162	1725263	2187786	1599953	1527613	1177561	1561893	659855	4855541	670179	1454371	858241	540522	928217	2067460	900679
14	Somogy	2874453	8481305	1474742	1421187	395259	1570196	941780	1714866	249731	193609	872555	104388	847448	5777399	229182	174162	5685534	794747	751635	615024
15	Szabolcs-Szatmár-Bereg	5206320	365049	2038259	1156382	3322907	1722363	493692	745187	8971671	2256958	359641	1382027	1435006	280095	6831263	10007325	239312	406220	401518	394579
16	Jász-Nagykun-Szolnok	3670702	259556	1147884	753616	3514671	1043428	356771	584173	9259703	1633892	265737	1051286	844571	209965	10006442	5592484	160930	327053	311284	316411
17	Tolna	2395189	6782503	948497	1054042	333950	1104125	783377	1508493	204623	161159	737607	87686	672808	5689407	195300	131892	3948884	808431	733372	690781
18	Vas	3419860	1298249	598279	499135	857768	584367	2054838	6635302	621398	431691	1499158	233196	983424	877098	561869	454688	890520	2740997	1155384	3196072
19	Veszprém	7100179	1015989	893929	805672	630054	927606	9032995	1922342	272261	304438	7589651	164356	2064585	637952	247255	193142	615242	959421	5709019	887771
20	Zala	3324664	1081056	543755	476145	835262	537970	1959287	8019488	603368	419586	1526829	226108	959744	678833	546969	441103	761747	3195818	1068209	2658974
Sum		169 907 111	42 143 223	47 641 745	37 525 670	67 379 503	43 499 278	53 965 824	52 597 475	49 970 752	35 263 896	40 803 761	20 841 332	48 560 363	33 866 862	47 471 104	40 845 145	27 991 308	27 530 305	43 639 469	27 886 952

3. Table Time costs for industrial goods on road [Euro] (GIVH time costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	112806	47140	76444	85744	157661	96458	66478	74753	87925	48870	44317	25113	74341	32488	86495	42599	24003	47204	90122	44887
2	Baranya	58619	46801	18310	25378	8558	25254	19043	36745	4940	4113	19262	2211	16766	87373	4774	3257	60703	17341	16431	12940
3	Bács-Kiskun	80456	16197	53160	103017	12953	78827	10485	14001	30748	5121	11124	3250	17639	17724	32531	12930	8114	7659	12244	6764
4	Békés	91745	22453	103231	23025	8222	57611	13938	12314	11516	4021	10906	2467	22695	19718	16515	7710	13936	6628	12343	6251
5	Borsod-AbaŁj-Zem	156398	7340	12519	7942	98374	11683	12023	24048	41641	93301	8490	77178	42202	5736	30427	40643	4668	13167	10338	12763
6	Csongrád	103032	22332	78892	57622	12081	36545	14110	14632	24345	5255	12503	3278	24389	21217	26818	12012	13131	7598	13605	7044
7	Fejér	66215	16121	10623	14033	12085	14333	60915	35875	5252	4901	72173	2553	20946	8037	5034	3002	6308	22977	76958	20976
8	Győr-Moson-Sopron	76386	40203	16003	14020	24787	16726	42954	72126	17371	11597	22433	5952	22976	25505	15814	11919	23526	60221	23816	99092
9	Hajdú-Bihar	85888	5943	29728	11133	47668	23537	8390	12884	51026	29572	6070	21655	22272	4959	77632	101450	3860	6981	7127	6753
10	Heves	48125	3555	4962	3889	93414	5079	4822	11201	26471	32871	3269	30478	10830	2672	28048	14790	2100	6462	4622	6199
11	Komárom-Esztergom	44241	16382	11246	10951	8533	12638	72055	18597	3810	3327	19730	1577	13784	10106	3614	2207	8237	16821	82928	17634
12	Nógrád	24798	1911	3157	2385	77326	3171	2536	5784	19387	30523	1560	6792	6193	1419	18745	12066	1130	3397	2443	3301
13	Pest	74481	13472	16715	21386	42796	22997	21027	22506	22808	11006	13827	6284	23430	9815	23290	8158	7009	13699	27103	13131
14	Somogy	40426	87287	20010	22208	6612	23957	9487	23292	4114	3094	11795	1639	12146	37670	3820	2644	53425	10040	7434	5444
15	Szabolcs-Szatmár-Bereg	84528	5721	31436	15965	33997	25927	8031	11734	77630	31291	5768	20870	22766	4599	46182	136210	3773	6294	6537	6120
16	Jász-Nagykun-Szolnok	41833	3926	12525	7455	45418	11616	4837	8885	101445	16521	3542	13481	7984	3230	136210	34436	2295	4975	4634	4761
17	Tolna	29903	60702	9170	15685	5476	14844	7450	21504	3214	2441	9715	1311	8733	53594	3169	1897	23406	11591	8772	9036
18	Vas	48235	18978	8776	7532	13578	8705	27569	60226	9406	6688	20197	3509	13992	10990	8481	6678	12686	15623	11484	28450
19	Veszprém	90082	13907	12440	12436	10356	13770	77062	19849	4451	4662	83025	2455	27020	6302	4085	2874	7426	9572	29609	7495
20	Zala	45774	14117	7737	7136	13152	8048	25183	99103	9088	6410	21161	3407	13368	5958	8245	6362	9845	28454	8993	14746
Sum		1 403 972	464 487	537 086	468 941	733 048	511 725	508 395	600 058	556 587	355 585	400 867	235 460	424 472	369 111	579 930	463 844	289 581	316 703	457 544	333 787

4. Table Forwarding costs for agricultural goods on road [Euro] (GAVH forwarding costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	611172	34431	68280	62408	111885	69950	80517	56803	59894	48741	58638	26174	189207	24177	55675	39435	20378	33515	75360	32414
2	Baranya	42872	85601	16323	17382	5511	18299	15217	26037	3294	2757	13545	1498	12003	89606	3152	2242	71436	12339	12792	10269
3	Bács-Kiskun	72377	14456	81875	85927	8857	86661	9788	9625	22095	4042	8578	2380	18091	13780	22243	12536	8858	5303	9346	4811
4	Békés	66078	15356	85865	39512	5959	61644	9859	8020	11010	3056	7521	1775	17197	13252	12611	8215	9828	4435	8456	4209
5	Borsod-AbaŁj-Zem	109650	4765	8572	5767	178220	7996	7920	15354	38335	112793	5757	71817	30387	3601	31366	33201	3061	8477	6636	8232
6	Csongrád	74578	16172	86742	61633	8263	63096	10874	9470	18174	3939	8719	2296	19584	14657	18781	11373	10306	5190	9724	4758
7	Fejér	80069	12892	9903	9880	7899	10946	108251	30422	3447	3680	90783	1999	23014	8374	3195	2331	7003	17790	95506	16958
8	Győr-Moson-Sopron	57475	28480	11025	9160	15803	10752	36557	115812	11164	7740	23200	4191	16875	19701	10148	8023	17312	69585	24021	84127
9	Hajdú-Bihar	58708	3967	21362	10646	42821	17575	5545	8310	91265	24842	4058	15827	15803	3170	94704	97751	2601	4555	4604	4413
10	Heves	47477	2380	3906	2955	112739	3809	3678	7500	22228	53857	2660	34486	12213	1755	21304	15418	1477	4254	3194	4119
11	Komárom-Esztergom	57957	11454	8610	7509	5735	8596	90877	19283	2512	2659	53374	1388	16348	7744	2324	1726	6594	12956	80168	13207
12	Nógrád	25611	1295	2295	1717	71841	2213	1992	4046	14158	34474	1385	14791	6836	948	13045	9921	805	2297	1725	2222
13	Pest	189249	9643	17083	16238	30888	18218	23102	16555	16130	12434	16493	6968	51248	7077	15356	9062	5707	9604	21831	9319
14	Somogy	30307	89557	15572	15007	4174	16580	9945	17979	2637	2045	9214	1102	8935	61005	2420	1839	60035	8332	7937	6448
15	Szabolcs-Szatmár-Bereg	54605	3795	21492	12193	35041	18161	5152	7563	94701	23801	3753	14574	15051	2912	72108	105633	2488	4123	4190	4004
16	Jász-Nagykun-Szolnok	38499	2698	12103	7946	37064	11002	3723	5929	97741	17230	2773	11086	8858	2183	105623	59032	1673	3319	3248	3211
17	Tolna	25254	71619	10016	11130	3527	11659	8272	15815	2161	1702	7789	926	7094	60076	2062	1393	41697	8476	7744	7242
18	Vas	34064	13506	6062	5057	8739	5921	21329	69583	6127	4398	15561	2376	9796	9125	5540	4483	9264	28744	11993	33517
19	Veszprém	74821	10729	9439	8507	6653	9795	95382	20023	2874	3215	80141	1736	21756	6737	2610	2039	6497	9993	60283	9247
20	Zala	33116	11247	5509	4824	8510	5451	20337	84099	5949	4275	15848	2304	9560	7062	5393	4349	7925	33514	11088	27884
Sum		1 783 937	444 042	502 033	395 399	710 127	458 323	568 317	548 228	525 896	371 678	429 789	219 693	509 854	356 943	499 660	430 000	294 946	286 802	459 845	290 613

5. Table Time costs for agricultural goods on road [Euro] (GAVH time costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	140848	338636	147088	251837	719281	249059	137488	323990	502145	177955	124217	119247	96121	188245	567007	172477	129015	224242	234762	216200
2	Baranya	274584	26385	20115	31212	30988	20370	36541	98214	116447	12221	39264	7956	69158	52284	178431	51531	27924	52345	38145	26360
3	Bács-Kiskun	88596	30770	21987	100604	403369	44155	153081	116103	146396	133193	106051	84859	13650	45302	181657	34007	6574	84466	112467	51318
4	Békés	111095	47932	65914	11327	326241	24553	176009	89531	45580	115438	105441	57905	29117	43575	89490	29606	37772	52595	99566	49057
5	Borsod-AbaŁj-Zem	523365	218965	159613	131421	663969	270761	371575	256078	189457	622106	387792	890587	200099	154646	69225	284088	132562	145324	293432	145462
6	Csongrád	101233	48722	45499	31973	446978	13721	218000	107605	123879	137667	117609	80274	28943	51458	150270	28353	37266	69289	118883	59276
7	Fejér	121020	126350	50945	56453	673584	57199	123092	164317	361346	234091	140558	192686	21241	38926	422163	132659	25898	112580	176325	105688
8	Győr-Moson-Sopron	314306	95581	62464	56942	186032	61082	79594	86136	128897	79552	35250	69564	99803	52034	102018	44499	43478	90060	34595	221455
9	Hajdú-Bihar	623296	134225	121965	53658	136825	161708	164333	179639	47076	67599	140721	51914	138846	112538	68559	99022	106697	99951	111992	98201
10	Heves	129185	110551	65319	59750	622106	103138	151177	129211	91661	130046	150738	125560	27558	79481	147346	47006	62836	71076	134420	71567
11	Komárom-Esztergom	77242	148741	35380	39799	487541	41235	140558	46652	287024	176613	63363	139568	20826	94846	249352	98526	64102	64850	278766	90670
12	Nógrád	97131	60128	39490	36281	945509	51951	83153	70133	100931	125560	79991	38593	16705	43371	108794	45864	31841	38343	73632	38548
13	Pest	96121	99269	24262	66666	198297	55720	24132	125881	114154	27622	23659	16744	13454	64456	140374	25375	43510	67529	74111	66653
14	Somogy	150063	59106	25539	24358	20924	22299	10116	66637	106190	8227	26519	5903	47642	16778	144757	45485	25171	28787	9355	6682
15	Szabolcs-Szatmár-Bereg	832758	136050	118006	95757	42409	212934	156708	169028	68559	105385	134146	50732	157772	104979	31672	225277	95530	88918	108776	88245
16	Jász-Nagykun-Szolnok	159701	91768	33083	37148	142635	34297	106495	129392	69979	28783	79072	26327	31758	84752	153624	29648	66854	70649	76454	69405
17	Tolna	100741	27924	3875	23489	18299	14628	10123	64690	81027	6944	22526	4834	34025	25171	111959	36582	7859	35354	17312	20369
18	Vas	244410	38323	39863	33043	106938	34501	51025	99786	73875	44634	40279	36255	59281	20484	62961	25077	21036	19489	18192	49345
19	Veszprém	257119	116753	48629	48545	568302	49297	176325	45786	372376	222132	247596	177116	64296	24575	381953	127424	43003	24076	64891	20587
20	Zala	279911	25453	36308	35056	105377	33060	48024	189056	65640	44055	48936	33732	58702	6325	75555	24420	14561	41465	15555	15783
Sum		4 722 726	1 981 632	1 165 344	1 225 319	6 845 605	1 555 668	2 417 550	2 557 865	3 092 639	2 499 822	2 113 732	2 210 356	1 228 995	1 304 225	3 437 167	1 606 927	1 023 489	1 481 387	2 091 632	1 510 874

6. Table Forwarding costs for industrial goods on railway [Euro] (GIVR forwarding costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	4877426	805843	982135	744643	2482348	914360	1467553	1190272	1428902	1263451	1085741	681708	1380357	631019	1307662	1071178	532134	646931	1175257	633478
2	Baranya	865116	521377	79363	63503	67045	75930	161751	223362	257821	35093	126455	18962	242701	446400	238309	195936	368499	112696	126519	104889
3	Bács-Kiskun	552546	134635	420984	329778	964781	387193	504185	281726	508375	497811	373098	272756	147012	116705	463673	366369	87568	149486	394927	142098
4	Békés	418934	107728	329778	210788	676785	269987	379726	207423	332766	353964	277274	194938	114372	89347	319338	261196	74433	111134	296470	109092
5	Borsod-AbaŁj-Zem	2476598	394756	556944	390691	11768300	497162	1132450	604575	1154753	6561302	826567	3870905	683126	313018	958563	949405	265018	325473	881941	319841
6	Csongrád	514416	128810	387193	269987	861223	323157	466953	254921	448794	447285	340602	245028	139016	109025	413299	321525	89272	136971	364072	133903
7	Fejér	1291771	413824	188652	142083	1942049	174721	2881660	668332	793040	1002535	2134708	544617	352076	314126	721190	597679	265161	356723	2204987	348351
8	Győr-Moson-Sopron	1355462	211425	182249	134183	493442	164909	504984	1413288	201749	260192	349799	140909	388978	164342	182992	154820	142305	760301	358096	786572
9	Hajdú-Bihar	1788336	266272	497090	325380	595544	438832	420400	408270	842067	319990	306536	186311	487250	217340	752211	703244	182506	218546	327636	214779
10	Heves	1260524	206624	287374	204335	6561302	258207	584599	318793	620457	3489480	428874	1912539	335653	163250	578329	482246	138011	170050	458684	167260
11	Komárom-Esztergom	955692	323522	139603	103748	1417487	127444	2134708	462949	578249	735479	1541599	397204	260221	254284	526415	437708	216026	260199	1690068	262466
12	Nógrád	680129	111647	157455	112533	3870905	141448	317577	172645	361256	1912539	231618	1017113	181946	88384	326601	272137	74742	91915	248278	90360
13	Pest	1380357	226073	261309	203293	684712	247098	399985	341573	389319	336432	295632	182368	375373	178664	358272	280658	148874	181820	330952	178943
14	Somogy	677433	446400	68794	52667	53163	64267	122782	173621	210442	27726	99392	15011	191805	348618	191348	160777	302446	87409	92155	77925
15	Szabolcs-Szatmár-	1636599	246121	453380	312249	494362	404125	382311	370312	752211	298263	279059	168439	448394	197620	646776	666264	165791	196477	297836	193631
16	Jász-Nagykun-	1340628	202359	358237	255398	489639	314388	316836	313302	703244	248710	232034	140350	351256	166048	666264	545103	139111	166732	249676	163870
17	Tolna	571275	368499	51619	43876	45011	52623	103643	150339	176713	23440	84438	12694	159824	302446	160529	134695	250708	77793	83515	73008
18	Vas	736715	106673	96703	71893	265644	88607	269536	760301	107996	138791	196604	75019	207053	82738	97090	82392	73636	375476	185109	382122
19	Veszprém	1034486	323687	147771	110931	1512450	136226	2204987	473930	618052	786602	1690068	425775	291311	235770	561836	470988	213665	244986	1619801	239612
20	Zala	721394	99283	91923	70572	261047	86622	263210	786572	106134	136514	198317	73750	203777	73761	95684	80977	69106	382122	181048	361291
Sum		25 135 836	5 645 558	5 738 557	4 152 532	35 507 238	5 167 305	15 019 837	9 576 505	10 592 339	18 875 599	11 098 412	10 576 397	6 941 503	4 492 904	9 566 382	8 235 296	3 799 011	5 053 240	11 567 029	4 983 490

7. Table Time costs for industrial goods on railway [Euro] (GIVR time costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	31	42	49	61	1230	71	27	228	99	365	26	195	21	26	103	49	21	162	53	156
2	Baranya	50	479	315	428	144	466	1039	1137	17	71	1077	39	15	1198	16	12	507	538	992	399
3	Bács-Kiskun	3	20	392	1490	5477	1047	87	159	1336	2269	69	1332	0	24	1377	390	4	90	83	79
4	Békés	4	27	1490	202	3754	585	85	128	541	1655	62	993	1	23	875	314	18	72	73	70
5	Borsod-AbaŁj-Zem	229	90	334	229	489	310	114	57	511	458	83	754	62	69	213	487	58	32	97	32
6	Csongrád	5	29	1047	585	5090	245	102	154	1204	2257	73	1305	1	27	1272	338	19	88	87	85
7	Fejér	66	278	66	65	54	77	362	511	17	22	414	12	12	97	16	10	67	341	519	321
8	Győr-Moson-Sopron	23	623	10	8	269	10	260	1684	27	131	85	71	8	412	25	19	380	2219	84	3753
9	Hajdú-Bihar	189	60	195	79	4988	176	154	133	55	2277	111	2160	48	49	80	111	40	74	129	73
10	Heves	68	44	138	101	458	138	47	28	233	96	35	92	9	32	330	113	27	16	44	16
11	Komárom-Esztergom	63	288	52	47	39	56	414	168	12	17	186	9	11	195	12	7	164	244	900	281
12	Nógrád	36	24	81	61	754	80	26	15	221	92	19	28	5	18	222	112	15	9	24	8
13	Pest	21	12	7	16	332	17	5	80	25	47	5	29	3	8	27	6	6	48	17	48
14	Somogy	32	1198	381	364	110	430	361	752	14	52	730	28	10	305	13	10	457	335	273	94
15	Szabolcs-Szatmár-	197	58	201	128	2073	185	150	125	80	3223	109	2164	52	46	37	211	38	67	123	66
16	Jász-Nagykun-Szolnok	93	41	57	46	4747	49	92	93	111	1100	67	1093	11	34	211	34	27	53	87	52
17	Tolna	25	507	70	290	92	310	251	692	11	43	613	23	7	457	11	8	143	360	494	276
18	Vas	16	295	6	5	153	6	173	2219	15	75	124	41	5	184	14	11	197	381	44	944
19	Veszprém	128	265	63	55	46	66	519	165	14	21	900	11	40	73	13	10	132	87	191	74
20	Zala	16	219	5	5	150	6	163	3753	15	74	143	40	5	52	14	11	151	944	38	309
Sum		1 296	4 599	4 959	4 263	30 449	4 328	4 431	12 281	4 560	14 343	4 930	10 419	327	3 328	4 883	2 261	2 471	6 158	4 351	7 135

8. Table Forwarding costs for agricultural goods on railway [Euro] (GAVR forwarding costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	1070	134	275	208	4226	256	292	960	316	2151	216	1161	303	105	289	237	88	522	234	511
2	Baranya	161	9466	1437	1150	360	1375	4011	3143	43	188	3135	102	45	8105	40	33	6691	1586	3137	1476
3	Bács-Kiskun	18	89	7512	5885	15597	6909	327	452	4267	8048	242	4409	5	78	3892	3075	58	240	256	228
4	Békés	14	72	5885	3761	10941	4818	246	333	2793	5722	180	3151	4	59	2680	2192	49	178	192	175
5	Borsod-AbaŁj-Zem	788	224	951	667	8665	849	329	149	2297	4831	240	2850	217	178	1907	1889	150	80	257	79
6	Csongrád	17	86	6909	4818	13923	5767	303	409	3767	7231	221	3961	5	72	3469	2699	59	220	236	215
7	Fejér	709	1072	248	187	157	230	8481	2404	47	81	6283	44	193	814	43	35	687	1283	6490	1253
8	Győr-Moson-Sopron	97	1723	29	22	705	27	1221	27629	69	372	846	201	28	1339	63	53	1160	14864	866	15377
9	Hajdú-Bihar	602	153	622	407	22403	549	430	342	977	12037	314	7009	164	125	873	816	105	183	335	180
10	Heves	401	117	490	349	4831	441	170	79	1234	2569	125	1408	107	93	1150	959	78	42	133	41
11	Komárom-Esztergom	524	838	184	136	114	168	6283	1665	34	59	4537	32	143	659	31	26	560	936	4974	944
12	Nógrád	216	63	269	192	2850	241	92	43	719	1408	67	749	58	50	650	541	42	23	72	22
13	Pest	303	37	73	57	1166	69	80	276	86	573	59	310	82	30	79	62	25	147	66	144
14	Somogy	126	8105	1246	954	285	1164	3044	2443	35	149	2464	81	36	6330	32	27	5491	1230	2285	1096
15	Szabolcs-Szatmár-	551	141	567	391	18597	506	391	310	873	11220	286	6336	151	113	751	773	95	164	305	162
16	Jász-Nagykun-	452	116	448	320	18419	393	324	262	816	9356	237	5280	118	95	773	633	80	139	255	137
17	Tolna	106	6691	935	795	242	953	2570	2115	29	126	2094	68	30	5491	27	22	4552	1094	2071	1027
18	Vas	53	869	16	12	380	14	652	14864	37	198	475	107	15	674	33	28	600	7340	448	7470
19	Veszprém	568	839	194	146	122	179	6490	1704	37	63	4974	34	160	611	33	28	554	881	4767	862
20	Zala	52	809	15	11	373	14	636	15377	37	195	480	105	15	601	33	28	563	7470	438	7063
Sum		6 828	31 646	28 305	20 466	124 356	24 920	36 372	74 957	18 514	66 579	27 474	37 400	1 877	25 622	16 848	14 157	21 688	38 622	27 816	38 463

9. Table Time costs for agricultural goods on railway [Euro] (GAVR time costs part)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	11.55	40.92	30.19	43.53	37.58	39.42	22.74	36.89	41.56	25.12	21.83	24.52	15.11	34.80	45.54	28.86	32.04	43.69	33.83	42.59
2	Baranya	41.72	16.53	32.03	55.78	59.80	45.77	35.93	51.17	37.56	53.33	46.90	53.40	42.66	26.87	42.11	31.12	23.57	46.89	40.83	37.31
3	Bács-Kiskun	31.58	31.11	18.60	36.66	28.80	25.90	24.64	43.39	41.96	22.51	31.84	25.22	26.69	39.05	49.42	25.42	24.73	46.26	33.94	41.83
4	Békés	45.96	54.00	36.66	17.23	27.11	26.37	39.66	52.39	25.68	24.40	41.60	26.55	42.00	57.54	37.45	22.67	48.81	55.20	45.52	53.14
5	Borsod-AbaŁj-Zem	37.53	38.07	33.97	31.64	13.63	36.70	25.90	46.61	26.91	17.96	26.00	23.82	37.10	35.82	23.67	30.86	34.96	49.53	28.85	48.94
6	Csongrád	41.68	44.38	25.92	26.38	30.74	17.81	34.00	50.10	38.60	25.33	38.70	27.99	37.32	50.51	46.96	26.51	38.87	51.64	41.36	48.51
7	Fejér	23.00	31.46	28.71	46.72	20.79	39.91	15.41	30.99	22.54	16.85	20.02	17.27	24.86	21.97	24.66	17.35	20.94	36.74	20.65	34.83
8	Győr-Moson-Sopron	36.36	51.71	47.64	57.60	49.18	55.00	32.55	17.97	57.69	42.93	25.63	42.16	39.07	41.65	59.66	49.83	44.13	23.90	26.18	34.19
9	Hajdú-Bihar	39.75	40.06	41.83	25.68	29.95	38.67	34.73	45.52	16.95	32.79	34.74	41.73	37.78	40.19	23.26	29.25	37.99	47.93	38.42	47.26
10	Heves	24.92	34.39	26.60	28.91	17.96	30.44	20.82	40.70	29.72	14.12	20.47	18.94	21.79	31.50	34.31	23.13	29.99	44.92	24.75	44.09
11	Komárom-Esztergom	21.99	41.02	37.57	49.20	20.42	45.62	20.02	24.27	22.62	16.38	12.62	16.06	23.36	32.44	23.83	17.46	31.57	36.60	26.52	38.63
12	Nógrád	24.42	34.43	29.93	31.85	23.88	33.64	20.66	39.73	37.80	18.95	19.25	12.34	22.79	31.26	40.79	30.86	29.96	44.27	24.54	43.75
13	Pest	15.12	41.89	25.53	40.00	37.12	35.32	24.54	39.63	39.52	21.85	23.12	22.84	15.45	37.46	44.67	22.09	33.19	45.55	36.10	44.67
14	Somogy	35.60	26.86	40.20	59.31	56.01	52.05	25.00	41.22	37.81	48.78	36.83	48.32	38.28	18.37	40.68	31.11	24.72	35.57	26.34	23.49
15	Szabolcs-Szatmár-	43.73	43.78	49.12	37.43	25.99	47.13	37.30	47.24	23.26	37.84	37.11	44.91	42.67	42.25	18.25	40.39	41.53	49.26	40.06	48.77
16	Jász-Nagykun-Szolnok	27.63	33.69	25.39	22.69	33.86	26.51	27.14	39.81	29.23	25.37	27.35	34.03	21.22	33.85	40.35	17.18	29.64	42.96	32.47	42.09
17	Tolna	32.65	23.60	25.46	50.25	54.91	40.01	23.78	43.74	35.45	46.22	36.04	46.31	33.84	24.77	39.82	27.31	16.72	45.50	33.16	37.55
18	Vas	43.18	47.33	50.64	60.56	52.32	56.69	38.63	23.91	60.80	47.47	38.62	47.04	44.97	35.91	62.44	53.90	45.87	15.94	24.90	22.49
19	Veszprém	34.33	35.52	40.40	54.40	23.08	49.36	20.65	24.88	25.45	19.81	26.52	20.30	36.60	23.14	26.87	20.51	28.85	23.69	14.60	20.74
20	Zala	42.21	37.65	46.06	58.62	51.70	53.30	36.62	34.16	59.81	46.59	40.66	46.43	44.13	23.73	62.01	52.65	37.82	22.48	21.76	15.85

10. Table Generalised cost/goods flow value ratios for industrial goods [-] (RIV)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	10.73	44.76	30.18	43.66	39.13	39.51	22.93	38.86	45.52	25.96	21.95	25.28	14.10	38.01	49.86	31.40	34.95	46.13	34.40	44.94
2	Baranya	44.72	14.84	28.53	49.47	57.66	40.69	30.21	45.52	58.90	51.49	39.19	51.49	45.78	23.98	64.57	48.89	21.04	41.71	34.25	33.32
3	Bács-Kiskun	30.22	29.91	16.69	32.71	24.06	23.18	28.65	47.95	39.99	19.45	37.97	21.40	25.52	37.57	46.99	24.28	23.76	50.90	40.58	46.26
4	Békés	44.12	52.13	32.73	15.49	22.64	23.58	47.40	58.26	24.58	20.68	50.14	22.47	40.29	55.56	35.76	21.68	47.02	61.33	55.18	59.01
5	Borsod-AbaŁj-Zem	40.11	58.31	44.09	40.60	15.34	46.81	47.34	58.28	28.36	20.81	46.23	27.85	39.53	54.99	24.94	32.49	53.45	61.95	53.66	61.13
6	Csongrád	40.00	42.78	23.20	23.58	25.29	15.99	40.13	55.64	36.83	21.57	46.53	23.53	35.77	48.71	44.72	25.32	37.36	57.16	49.89	53.69
7	Fejér	22.85	33.44	28.81	47.34	48.12	40.34	15.19	30.99	52.05	37.78	19.88	37.13	24.80	23.22	56.06	39.67	22.12	36.81	20.52	34.86
8	Győr-Moson-Sopron	39.22	47.70	49.73	60.29	56.25	57.57	31.87	15.87	61.46	49.01	25.02	47.65	42.18	38.46	63.68	53.37	40.76	20.97	25.57	29.73
9	Hajdú-Bihar	45.33	57.46	45.23	27.34	23.40	41.48	49.26	59.39	15.96	25.27	48.94	31.99	43.12	57.61	21.99	27.72	53.77	62.55	55.22	61.60
10	Heves	26.35	52.27	34.04	37.04	20.81	38.74	36.92	50.55	31.48	16.04	35.22	22.17	22.94	47.68	36.33	24.32	45.25	56.05	45.18	54.90
11	Komárom-Esztergom	21.82	43.72	38.02	49.93	46.96	46.28	19.88	24.25	51.69	36.03	12.33	33.08	23.23	34.39	55.29	39.98	33.55	36.74	26.46	38.71
12	Nógrád	25.74	52.31	38.64	41.05	27.88	43.36	36.45	49.23	40.12	22.18	32.45	13.73	24.03	47.22	43.29	32.70	45.35	55.17	44.65	54.44
13	Pest	14.11	45.81	25.46	40.06	38.64	35.35	24.86	41.68	43.31	22.53	23.35	23.58	14.43	40.92	48.96	23.81	36.17	48.10	36.74	47.14
14	Somogy	38.09	23.97	35.74	52.59	54.05	46.23	21.21	36.73	59.03	47.10	31.01	46.56	41.01	16.46	62.13	48.72	22.06	31.76	22.27	21.06
15	Szabolcs-Szatmár-	49.67	62.82	53.33	40.19	20.30	50.62	53.06	61.59	21.99	29.13	52.38	34.38	48.77	60.62	17.20	38.31	59.31	64.33	57.51	63.61
16	Jász-Nagykun-	31.31	47.77	27.15	24.04	26.25	28.38	37.72	51.61	27.72	19.87	38.03	26.22	23.72	47.71	38.31	16.18	41.12	55.91	46.18	54.67
17	Tolna	34.87	21.07	22.69	44.59	52.97	35.62	20.18	38.95	55.17	44.61	30.37	44.63	36.14	22.10	61.15	41.99	15.00	40.48	27.95	33.52
18	Vas	46.67	43.69	52.83	63.36	59.85	59.30	37.90	20.97	64.74	54.34	37.87	53.45	48.72	33.18	66.56	57.80	42.37	14.15	24.30	19.75
19	Veszprém	34.31	37.81	40.85	55.23	54.57	50.08	20.52	24.88	58.39	46.19	26.47	45.52	36.66	24.55	60.79	48.67	30.73	23.65	14.35	20.65
20	Zala	45.50	34.78	47.97	61.24	59.10	55.67	35.90	29.73	63.75	53.29	39.87	52.77	47.77	21.92	65.85	56.42	34.96	19.75	21.17	14.06

11. Table Generalised cost/goods flowvalue ratios for agricultural goods [-] (RAV)

kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	2.92	33.65	22.08	35.95	29.96	31.62	14.47	29.29	34.23	17.10	13.56	16.49	6.48	27.20	38.37	21.13	24.42	36.40	25.94	35.26
2	Baranya	34.39	7.87	23.67	48.44	53.08	37.94	27.93	43.87	31.55	46.30	39.35	46.39	35.36	18.32	36.37	24.74	14.91	39.34	33.07	29.36
3	Bács-Kiskun	23.31	22.86	9.93	28.46	22.48	17.31	17.13	36.40	34.74	15.91	24.61	18.73	18.25	31.10	42.58	17.51	16.26	39.45	26.83	34.80
4	Békés	38.25	46.73	28.46	8.56	20.72	17.80	32.78	45.88	17.79	17.87	34.81	20.14	34.14	50.45	30.06	14.67	41.29	48.94	38.99	46.76
5	Borsod-AbaŁj-Zem	29.91	32.12	27.33	24.91	5.88	30.19	19.73	40.12	19.08	10.21	19.83	16.29	29.49	29.68	15.71	23.15	28.80	43.26	22.88	42.64
6	Csongrád	33.74	36.65	17.34	17.80	24.53	9.14	26.89	43.43	31.24	18.87	31.76	21.65	29.27	43.06	40.01	18.66	30.93	45.17	34.64	41.84
7	Fejér	14.68	23.89	20.67	39.41	14.91	32.32	7.14	23.12	16.75	10.77	11.75	11.20	16.60	14.03	18.98	11.31	12.98	29.11	12.38	27.14
8	Győr-Moson-Sopron	28.77	44.38	40.42	50.89	42.58	48.10	24.52	9.45	51.09	36.02	17.34	35.26	31.62	33.86	53.20	42.84	36.42	15.44	17.91	26.08
9	Hajdú-Bihar	32.55	33.97	34.62	17.79	21.79	31.32	28.35	39.32	8.37	24.73	28.35	34.02	30.51	34.04	14.70	20.88	31.75	41.93	32.27	41.21
10	Heves	16.89	28.21	19.63	22.03	10.22	23.64	14.41	33.91	21.96	6.37	14.05	11.20	13.65	25.10	26.73	15.15	23.57	38.38	18.54	37.51
11	Komárom-Esztergom	13.66	33.85	29.84	41.99	14.53	38.19	11.74	16.16	16.82	10.30	4.35	9.95	15.05	24.89	18.14	11.43	24.01	28.96	18.44	31.08
12	Nógrád	16.39	28.27	23.09	25.11	16.34	26.98	14.26	32.94	30.38	11.21	12.80	4.58	14.69	24.88	33.48	23.15	23.56	37.72	18.35	37.16
13	Pest	6.49	34.65	17.24	32.27	29.50	27.38	16.33	32.15	32.13	13.70	14.87	14.74	6.82	29.98	37.48	14.06	25.59	38.35	28.31	37.44
14	Somogy	27.95	18.30	32.15	52.15	49.02	44.51	16.60	33.46	31.76	41.45	28.85	40.99	30.76	9.72	34.76	24.74	16.10	27.57	18.03	15.06
15	Szabolcs-Szatmár-	36.67	37.96	42.28	30.04	17.71	40.19	31.06	41.16	14.70	29.96	30.86	37.32	35.60	36.25	9.66	32.44	35.52	43.38	34.04	42.85
16	Jász-Nagykun-Szolnok	20.02	27.21	17.48	14.69	25.84	18.66	20.41	33.27	20.86	17.06	20.64	26.02	13.32	27.35	32.40	8.60	22.96	36.63	26.02	35.72
17	Tolna	24.95	14.94	16.88	42.64	47.90	31.96	15.34	36.06	29.31	38.83	28.04	38.94	26.18	16.15	33.88	20.75	8.06	37.91	25.10	29.63
18	Vas	35.91	39.75	43.61	54.12	45.95	50.02	30.84	15.45	54.44	40.82	30.82	40.40	37.80	27.88	56.22	47.17	38.24	7.42	16.58	13.98
19	Veszprém	26.39	28.15	32.82	47.51	17.37	42.23	12.38	16.79	19.83	13.91	18.43	14.40	28.77	15.29	21.36	14.67	21.21	15.55	6.32	12.53
20	Zala	34.91	29.67	38.80	52.07	45.30	46.41	28.76	26.06	53.41	39.91	32.95	39.74	36.94	15.26	55.75	45.88	29.86	13.97	13.35	7.33

12. Table Generalised cost/goods flow value ratios for industrial goods[41] [-] (RIV)

[41],[3] Without technological times

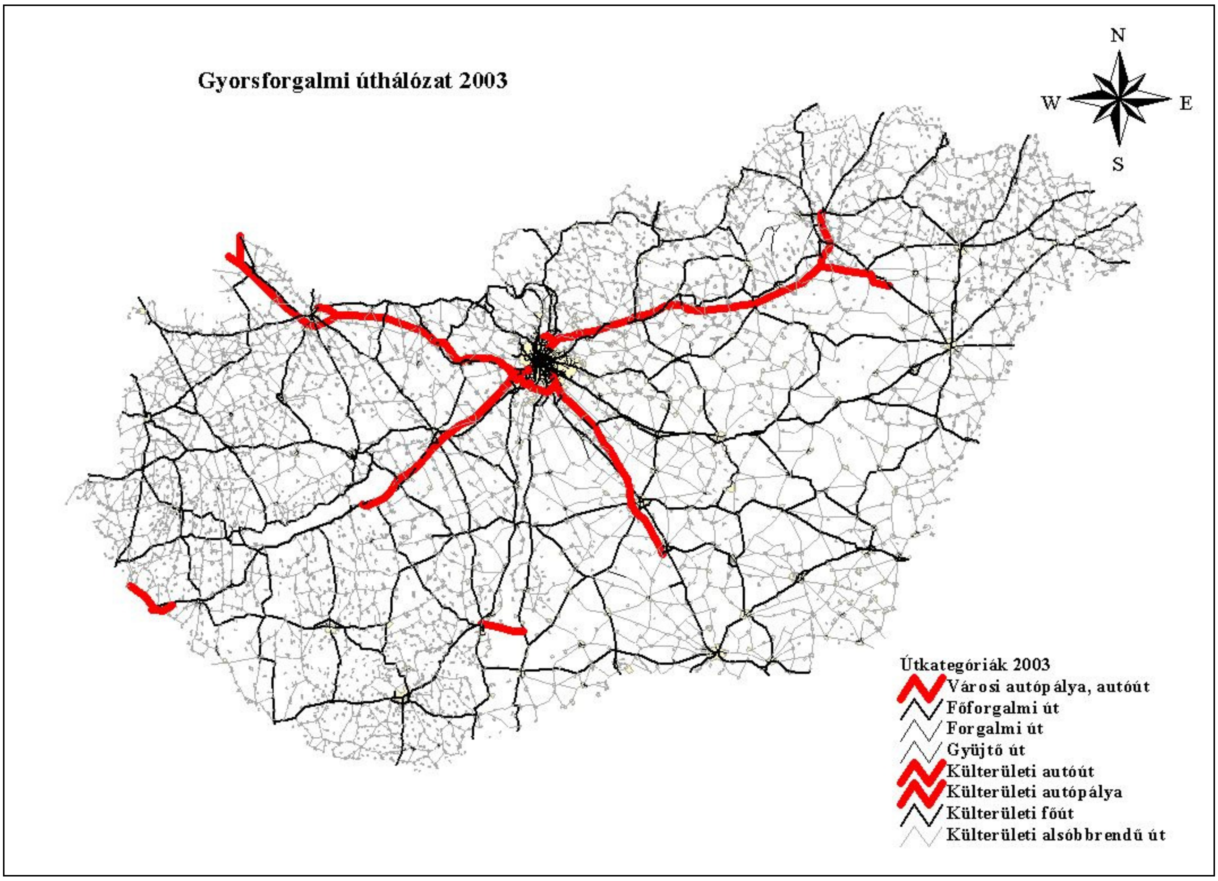
kód	megyék	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Budapest	2.77	37.69	22.50	36.52	31.78	32.13	15.05	31.53	38.39	18.19	14.06	17.50	6.14	30.58	42.88	23.83	27.50	39.12	26.90	37.89
2	Baranya	37.64	6.94	20.89	42.74	51.33	33.54	22.84	38.74	52.55	44.86	32.22	44.88	38.74	16.18	58.57	41.99	13.14	34.71	27.10	25.96
3	Bács-Kiskun	22.55	22.22	8.79	25.23	17.32	15.35	20.97	41.08	33.03	12.45	30.63	14.49	17.68	30.17	40.39	16.66	15.87	44.22	33.38	39.35
4	Békés	36.98	45.39	25.25	7.58	15.83	15.76	40.49	51.91	16.97	13.74	43.35	15.63	33.00	48.99	28.63	13.97	40.03	55.26	48.68	52.80
5	Borsod-AbaŁj-Zem	32.73	51.98	37.14	33.53	7.41	40.02	40.35	51.78	20.70	12.88	39.22	20.13	32.16	48.38	17.16	24.95	46.83	55.70	46.99	54.83
6	Csongrád	32.64	35.58	15.38	15.76	18.64	8.08	32.92	49.12	29.74	14.69	39.55	16.75	28.30	41.78	38.02	17.75	29.97	50.85	43.14	47.14
7	Fejér	14.97	25.99	21.13	40.40	41.10	33.12	7.27	23.44	45.25	30.39	11.97	29.75	16.97	15.39	49.43	32.41	14.26	29.50	12.60	27.49
8	Győr-Moson-Sopron	31.87	40.90	42.84	53.94	49.74	51.02	24.30	8.04	55.16	42.16	17.21	40.80	34.96	31.24	57.53	46.67	33.61	13.20	17.77	22.27
9	Hajdú-Bihar	38.21	51.11	38.22	19.62	15.95	34.32	42.49	53.09	8.00	17.88	42.16	24.90	35.93	51.17	14.06	19.97	47.21	56.50	48.76	55.49
10	Heves	18.54	45.62	26.68	29.82	12.88	31.60	29.55	43.69	23.91	8.11	27.82	14.25	15.02	40.74	28.93	16.51	38.27	49.48	38.15	48.28
11	Komárom-Esztergom	13.93	36.69	30.66	43.09	39.92	39.22	11.97	16.47	44.87	28.61	4.42	25.59	15.37	26.95	48.64	32.75	26.11	29.42	18.72	31.47
12	Nógrád	17.93	45.69	31.45	33.98	20.16	36.39	29.09	42.36	32.89	14.26	24.98	5.80	16.16	40.27	36.17	25.18	38.40	48.60	37.62	47.82
13	Pest	6.15	38.77	17.61	32.77	31.28	27.85	17.04	34.47	36.11	14.63	15.48	15.74	6.47	33.62	41.97	15.93	28.74	41.19	29.33	40.19
14	Somogy	30.68	16.16	28.39	46.02	47.46	39.33	13.50	29.54	52.60	40.18	23.68	39.64	33.73	8.56	55.87	41.83	14.19	24.36	14.64	13.26
15	Szabolcs-Szatmár-	42.70	56.82	46.72	32.98	12.73	43.89	46.46	55.44	14.06	21.91	45.77	27.39	41.79	54.35	9.25	30.96	53.06	58.41	51.19	57.64
16	Jász-Nagykun-	23.74	40.88	19.42	16.19	18.91	20.71	30.49	44.91	19.97	12.28	30.83	18.87	15.85	40.79	30.96	8.23	33.94	49.46	39.32	48.17
17	Tolna	27.41	13.17	14.86	37.63	46.35	28.28	12.44	31.83	48.60	37.63	23.02	37.67	28.71	14.23	54.89	34.79	7.10	33.44	20.54	26.18
18	Vas	39.65	36.67	46.14	57.29	53.59	52.98	30.57	13.20	58.69	47.78	30.53	46.89	41.81	25.73	60.65	51.37	35.31	6.32	16.45	11.93
19	Veszprém	26.81	30.57	33.65	48.72	47.89	43.32	12.60	17.11	51.93	39.15	18.73	38.49	29.26	16.82	54.46	41.81	23.21	15.84	6.44	12.75
20	Zala	38.45	27.38	41.04	55.03	52.80	49.12	28.50	22.27	57.65	46.69	32.61	46.17	40.83	14.08	59.89	49.95	27.58	11.93	13.24	6.23

13. Table Generalised cost/goods flow value ratios for agricultural goods[42] [-] (RAV)

[42] Without technological times

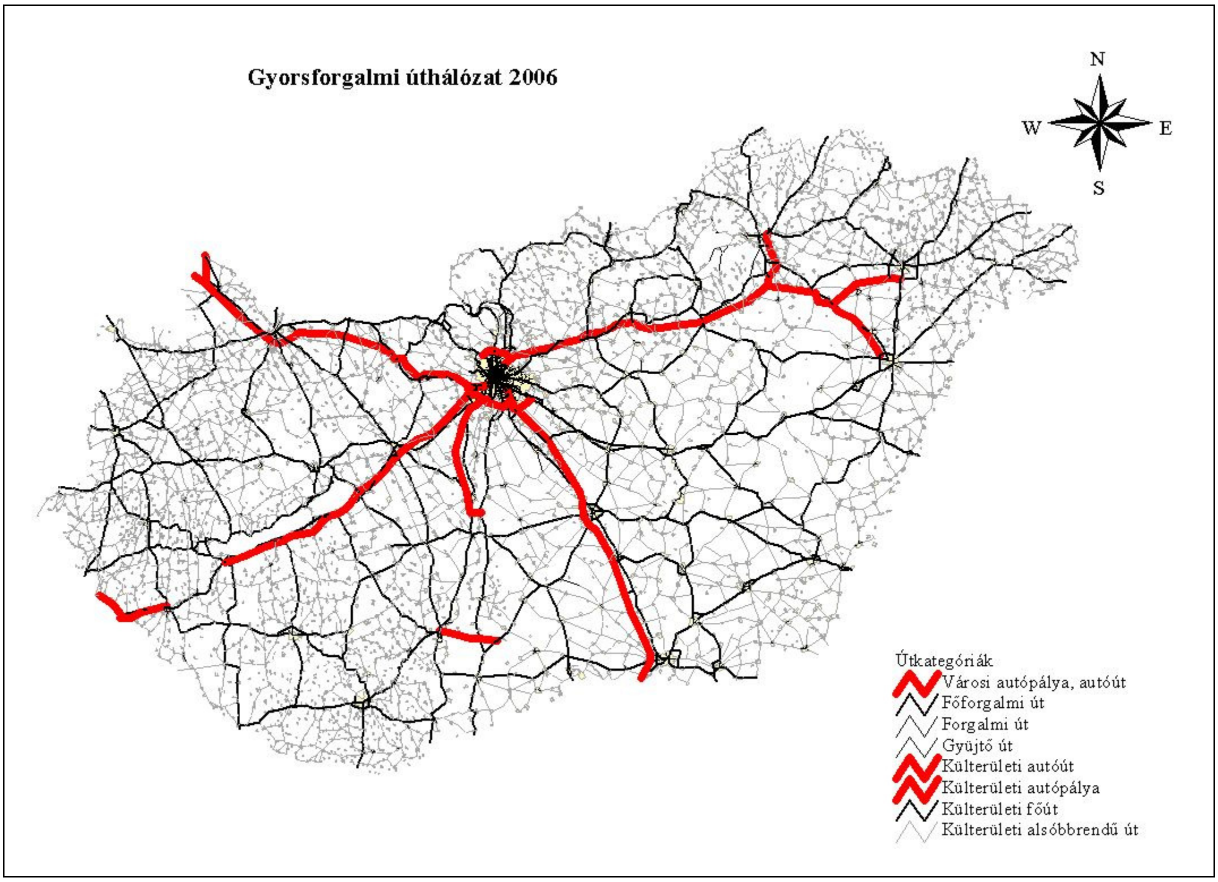
Appendix 5: The transportation cost matrices[43]

Three transport cost matrices are included in the software. These matrices represent road networks of Hungary in 2003, 2006 and 2012 according to the following systems.

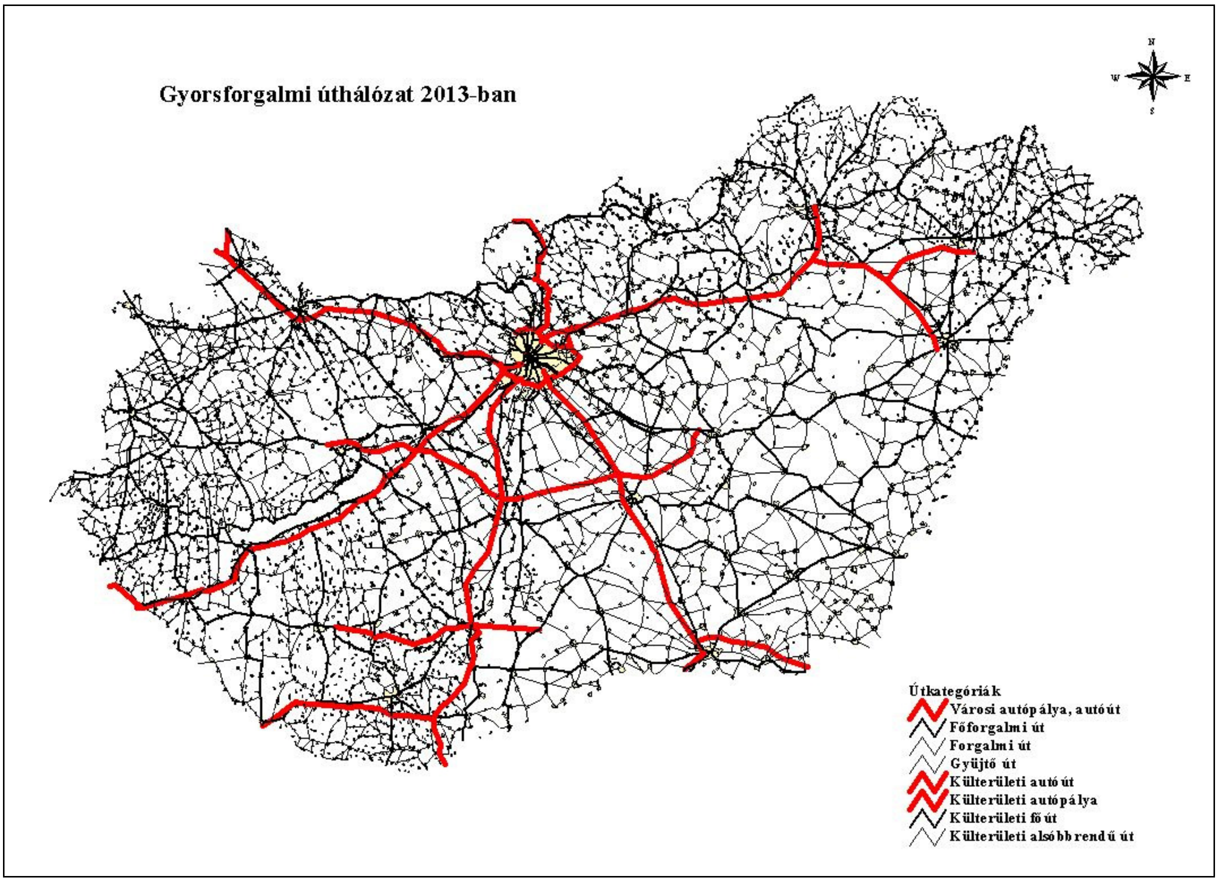


3. figure Road network model for 2003

[43] Written by János Monigl and Zoltán Újhelyi



4. figure Road network model for 2006

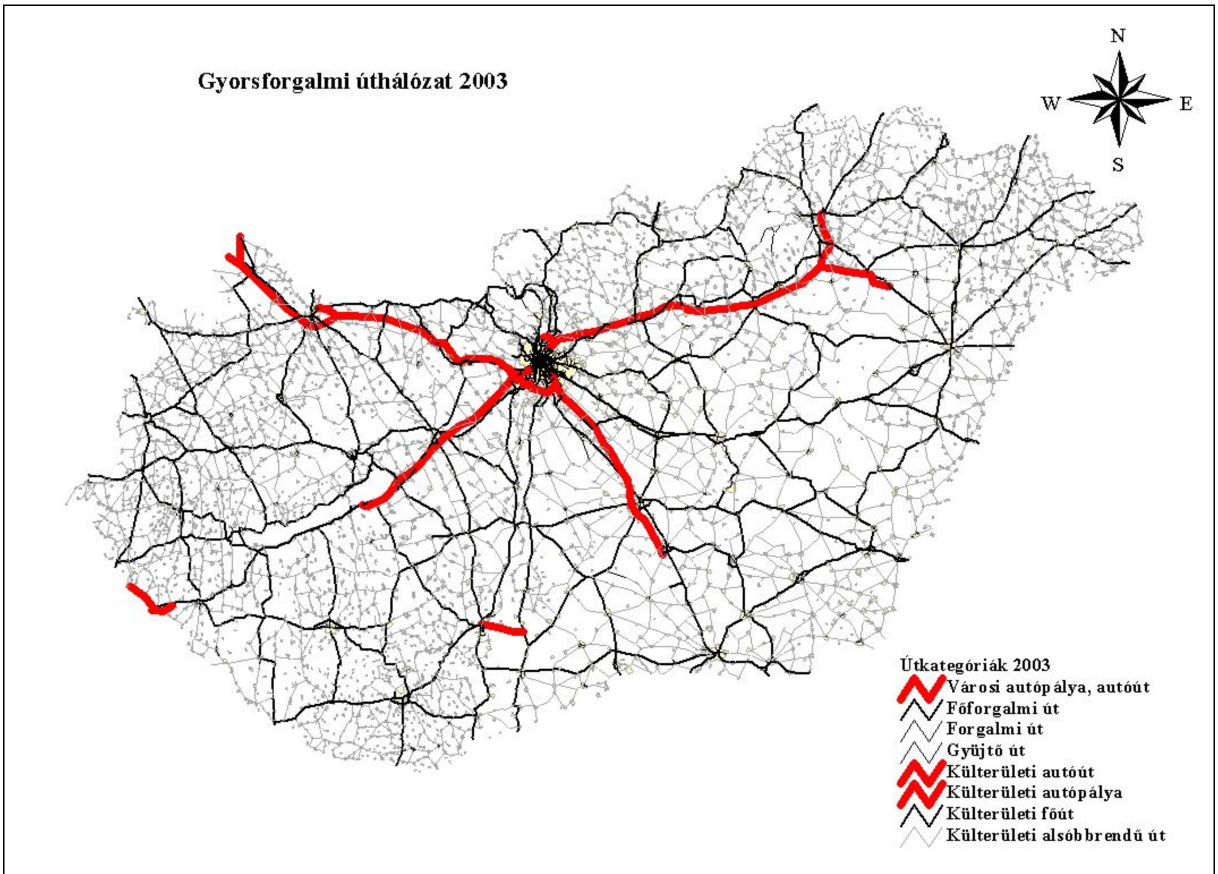


5. figure Road network model for 2013

Appendix 6: Generalised cost indicator calculation[44]

For the Hungarian economy the export-import relations are very important. The main direction of the foreign trade is toward the EU-countries, so an important ”gate” is the Austrian border, where Hegyeshalom is the main border station. Therefore it is necessary to know the accessibility of Hegyeshalom board from the 20 different counties in order to plan the export-import activity toward the EU countries. The changes of the accessibilities because of developments of the road infrastructure in the future will influence also the transportation costs and further the results of the economic models.

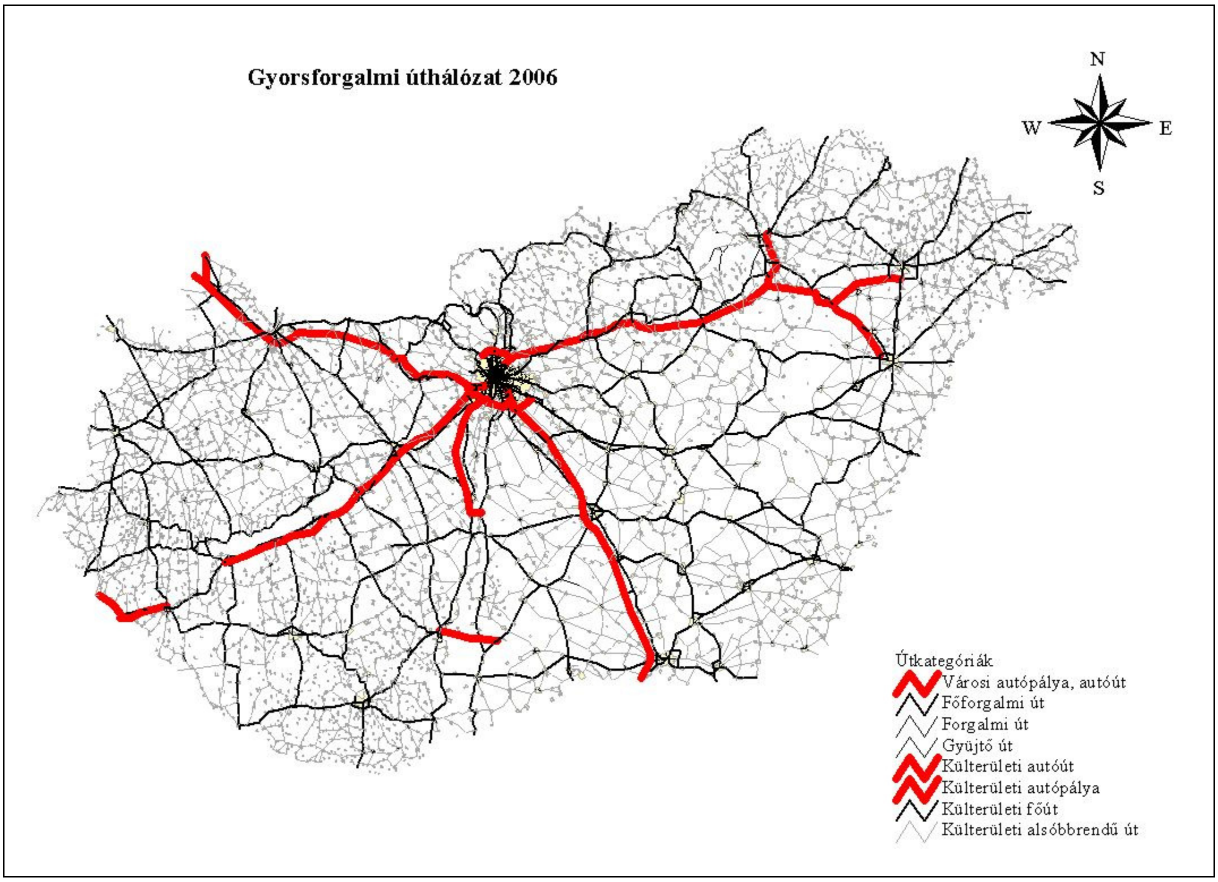
The nationwide road network model TRANSWAY is applicable to calculate these indicators.



6. figure Road network model for 2003

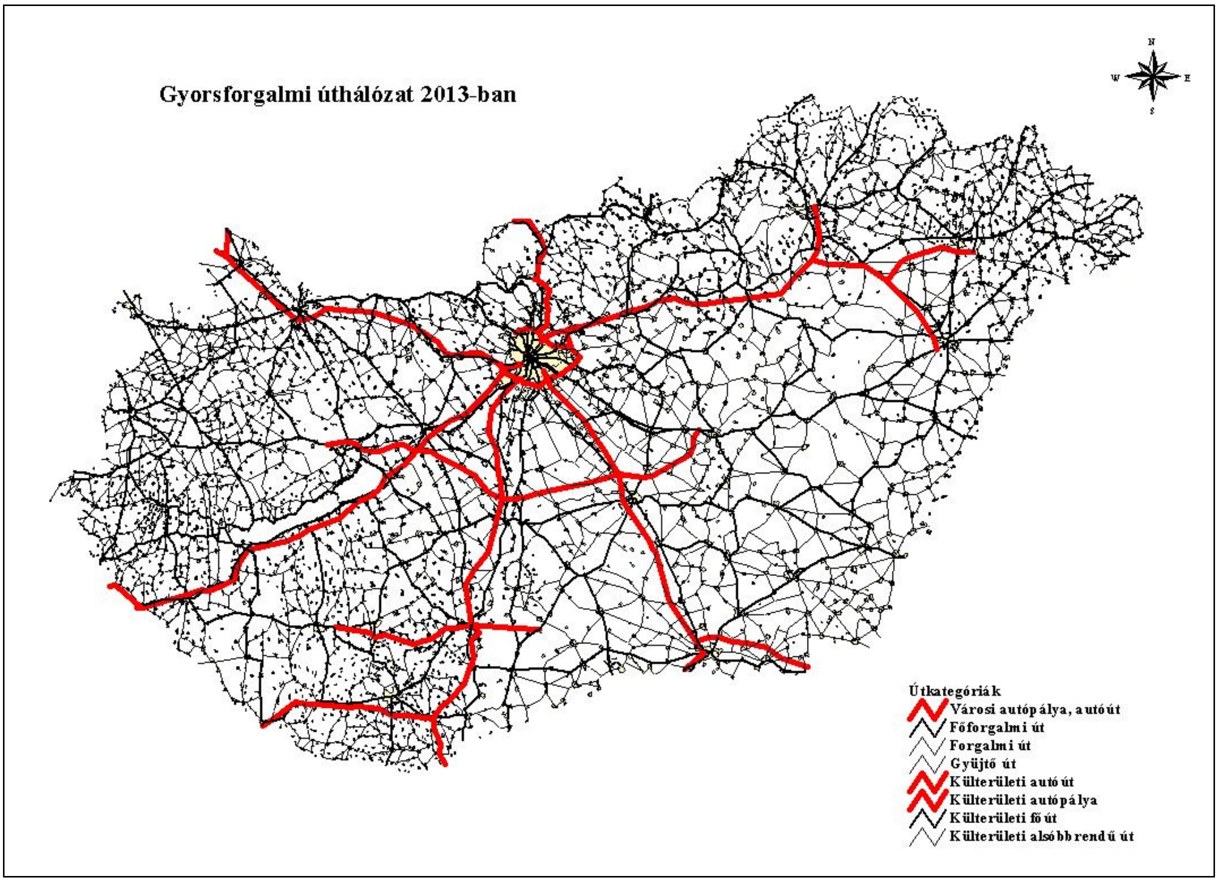
For the time period between 2003 and 2034 TRANSMAN developed four different road network models. One for 2003, 2006, 2013 and one for 2034.

[44] Written by János Monigl and Zoltán Újhelyi



7. figure Road network model for 2006

The transportation time between Hegyeshalom and any other point of Hungary is influenced by two contradictory factors. Developing the transport infrastructure, building new motorways and roads decreases the transportation time. But on the same time the developing economy generates new transport demands, causing increasing transportation time.



8. figure Road network model for 2013

After the assignment of the traffic flows on the transport network (with different demand matrices) the model calculates four different transportation time matrices. For our purposes we need only one row of the matrices, which contains the transportation times to Hegyeshalom from 20 counties of Hungary.(14. table)

Time	Budapest	Baranya	Kiskun	Békés	Abaúj-Zem	Csongrád	Fejér	Moson-	Bihar	Heves	Esztergo	Nógrád	Pest	Somogy	Szatmár-	Nagykun-	Tolna	Vas	Veszprém	Zala
2003 time(min)	184	244	255	357	325	322	155	26	367	273	122	272	198	164	391	298	216	33	119	104
2006 time(min)	185	242	245	348	321	305	152	26	354	270	122	267	198	157	374	292	210	3 3	118	104
2013 time(min)	183	243	244	351	320	302	151	26	361	271	122	270	196	157	361	296	210	34	11 8	103
2034 time(min)	168	252	237	327	331	294	154	22	344	265	125	261	186	155	383	261	215	33	128	106

14. table Transportation time for different network variants [min]

2003	Budapest	Baranya	Bács-Kiskun	Békés	Abaúj-Zem	Csongrád	Fejér	Moson-	Bihar	Heves	Esztergo	Nógrád	Pest	Somogy	Szatmár-	Nagykun-	Tolna	Vas	Veszprém	Zala
time cost for 1000€	295	391	409	573	521	517	249	41	588	438	195	436	317	263	627	478	346	53	191	166
weighted time cost	96	13	17	17	23	19	10	2	24	11	6	13	4	24	17	17	8	1	6	4

15. table Time cost calculation for 2003 [€]

The 15. table shows the time cost calculation for 2003. The time costs are in the first row of the table. In the second row are the weighted time costs for every county. Summing up these values we can get a so called "generalised cost indicator" (GCIH, **G**eneralised **C**ost **I**ndicator for **H**ungary) for the whole country , for each network variants. For 2003 the indicator (GCIH) is 332 €.

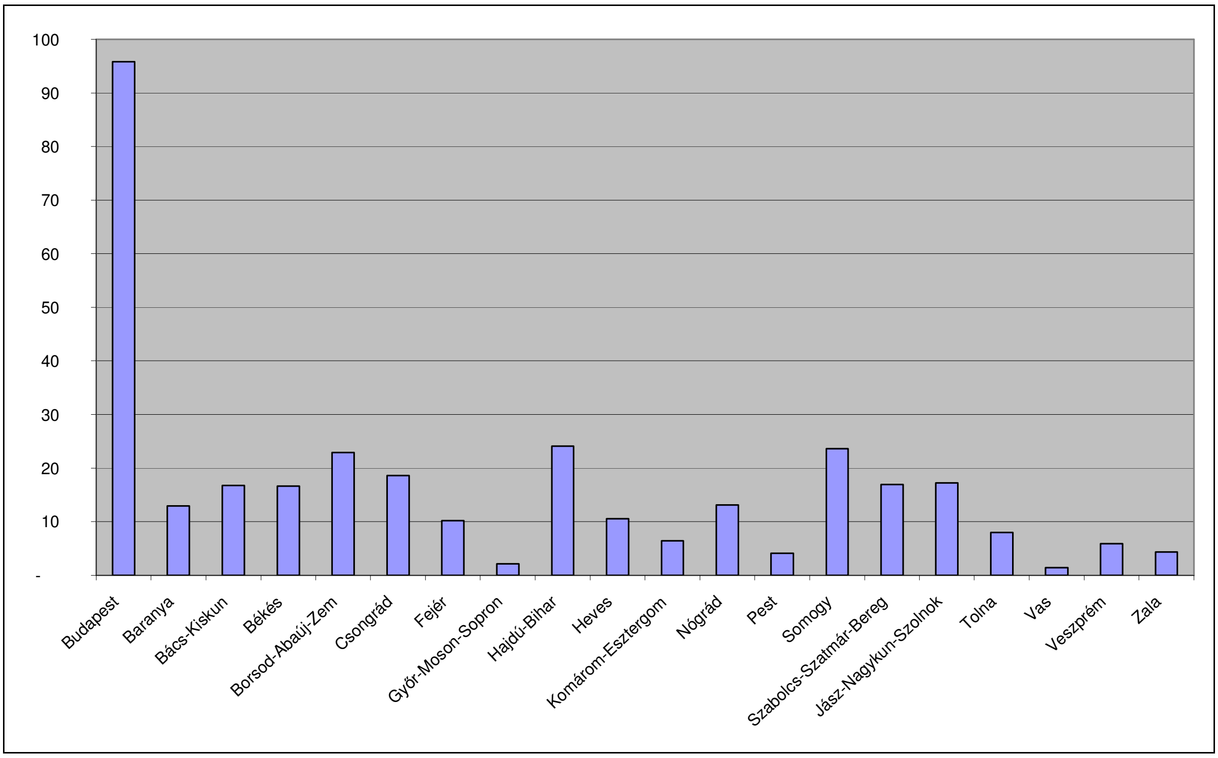
$$GCIH = \sum_{i=1}^{i=20} \alpha * GDPW_i * TH_i * KH * VOG ;$$

Where:

i: number of counties (from 1 to 20)

TH: **T**ransport time on road (**H**ighways) [hour]

KH:	Unit time cost (**K**) on road (**H**ighway)	60.00[45] [€/k€h]
VOG:	**V**alue **O**f **G**oods transported [1000 €]	
α:	Total cost and time cost ratio [-]	



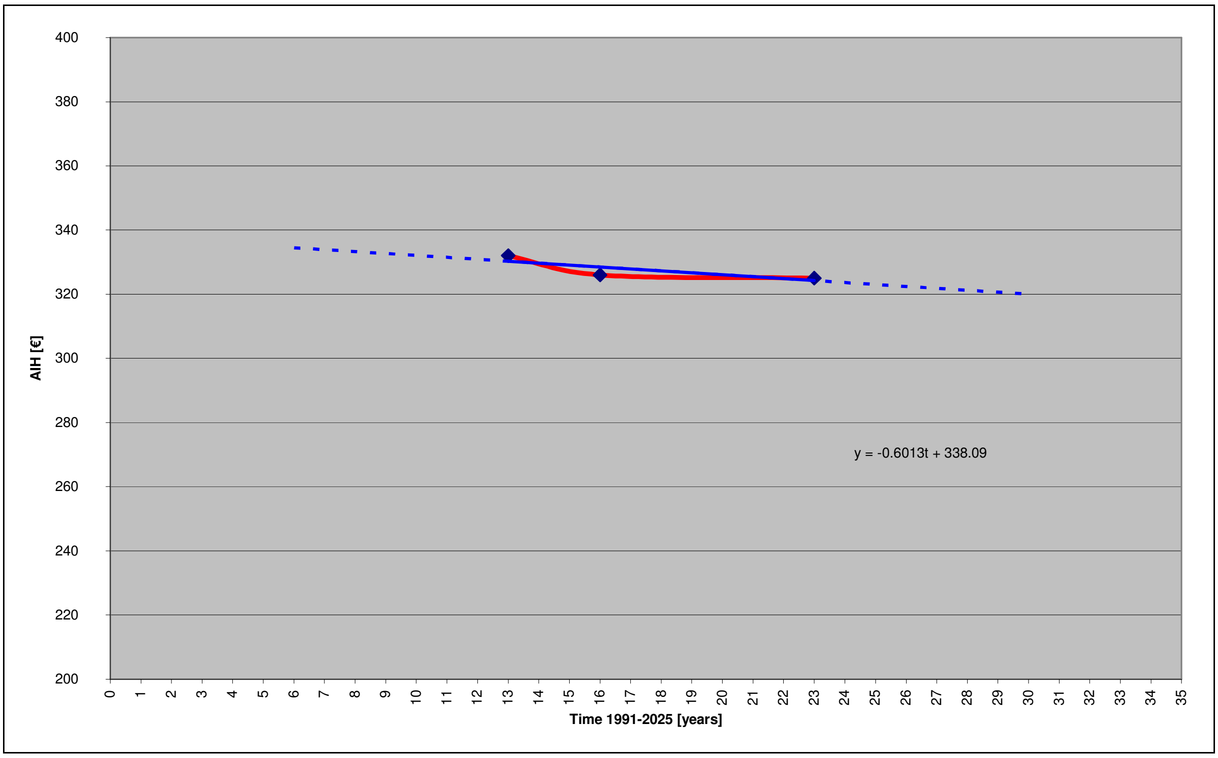
9. figure The weighted time cost of counties by GDP for 2003 [€]

The figure shows that Budapest has a big weight because of its high ratio of GDP. Calculating these indicators for every network variant we get an indicator set representing the whole country for different years.

Years	AIH before regression	AIH after regression
2003	332	330
2006	326	328
2013	325	324

16. table Accessibility indicators for four different years [€]

[45] At the HU time cost 33% of the NL level had been considered



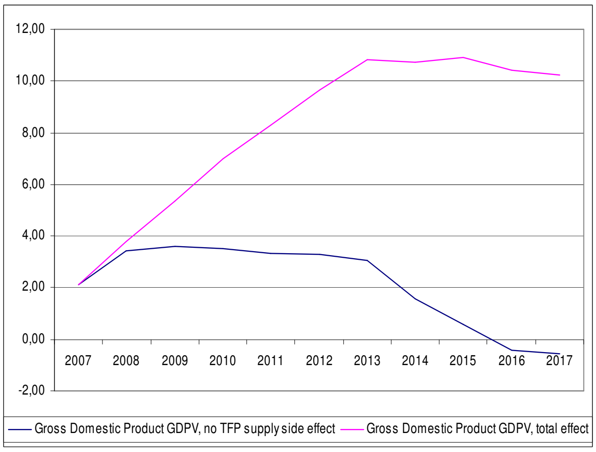
10. figure Diagram and trendline of accessibility indicator (GCIH) (first year is 1991)

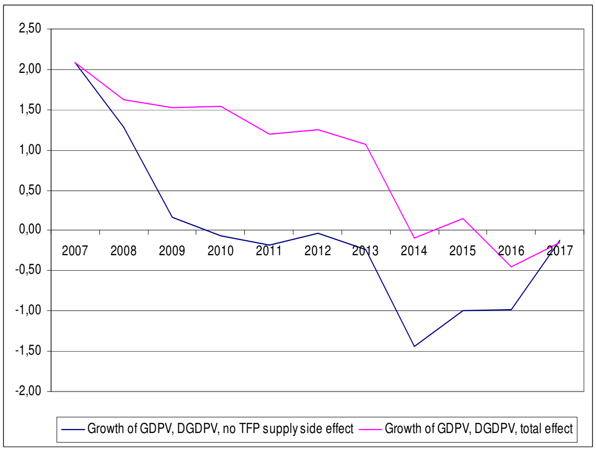
As one can see on this figure the accessibility of Hegyeshalom is slightly getting better, because the access time is decreasing. This is because developing of the road transport infrastructure is faster then the forcasted transport demand. You also can see the function of the trendline of GCIH in the following line.

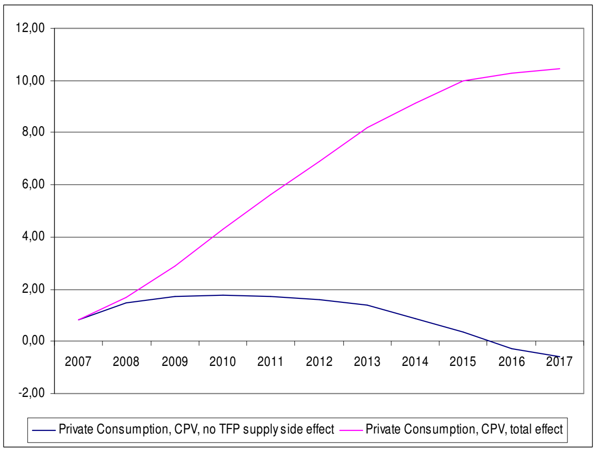
$y = -0.6013 * t + 338.09 \qquad t = 1 \qquad$ for 1991 year

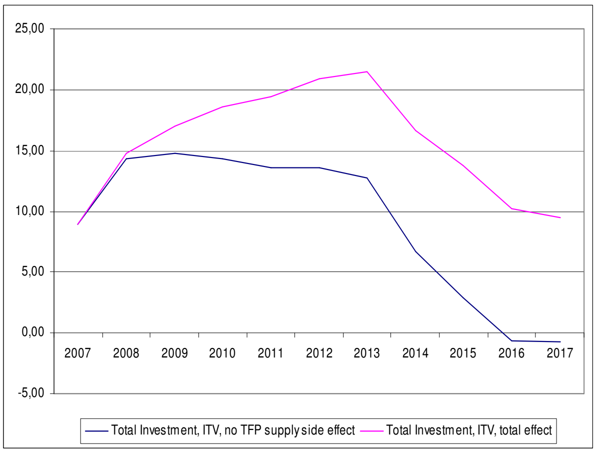
Using this function you can easily calculate the indicators (GCIH) for different time, as you can see in the 16. table the indicators before and after regression. But of course you have to take into consideration that the valid time interval is limited. You must not use this function before 1996 and after 2015.

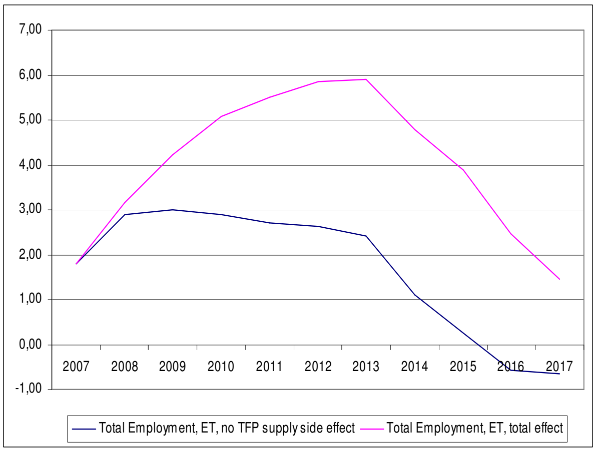
Appendix 7: The effect of CSF support: both EU and Hungarian co-financing is accounted for

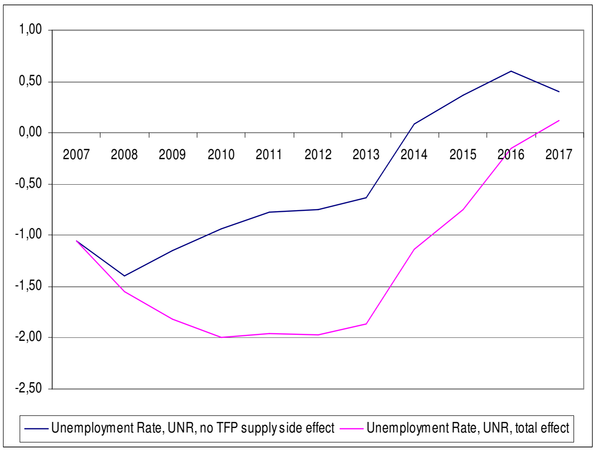


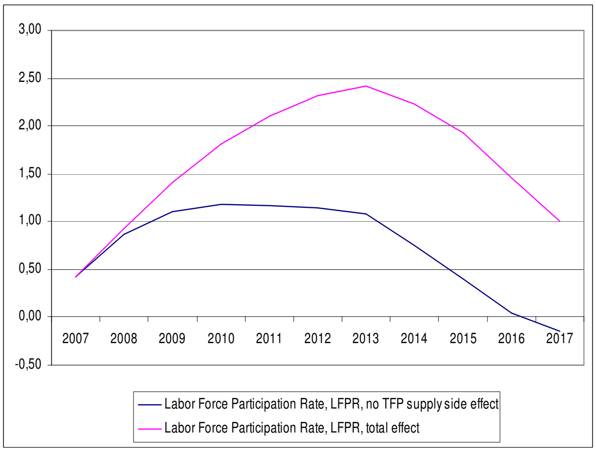











3,00
2,50
2,00
1,50
1,00
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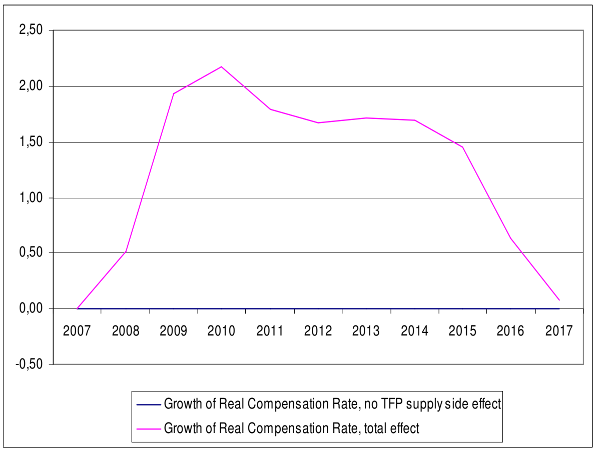
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Labor Force Participation Rate, LFPR, no TFP supply side effect
Labor Force Participation Rate, LFPR, total effect


2,50
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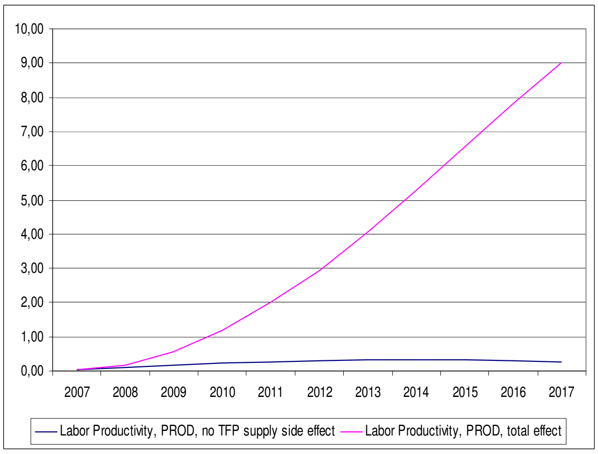
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Growth of Real Compensation Rate, no TFP supply side effect
Growth of Real Compensation Rate, total effect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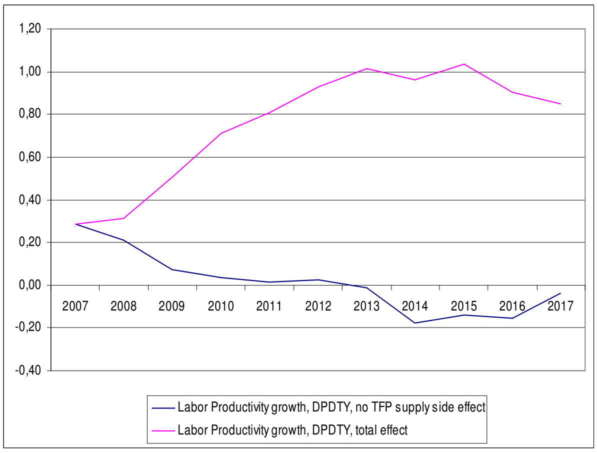
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Labor Productivity, PROD, no TFP supply side effect
Labor Productivity, PROD, total effect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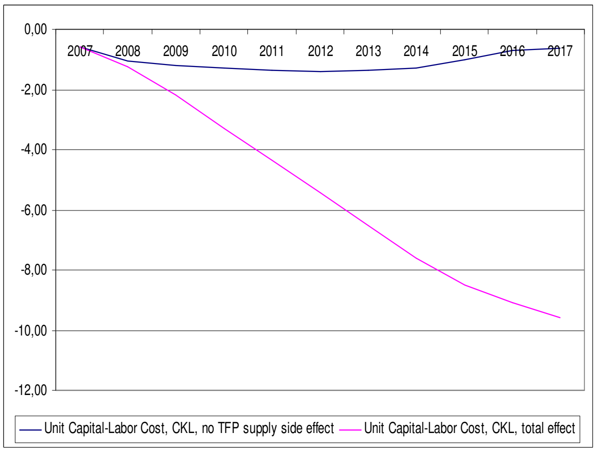
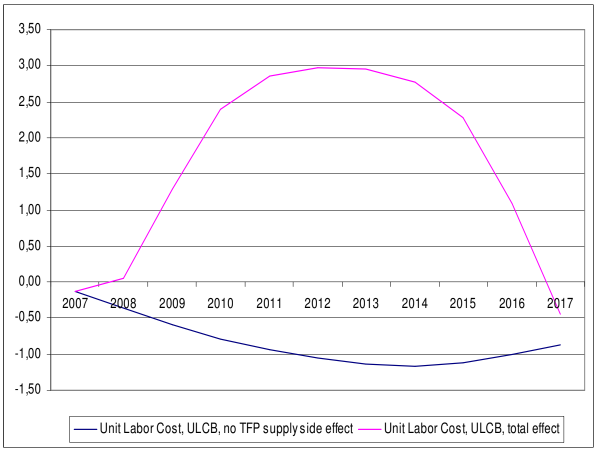
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Labor Productivity growth, DPDTY, no TFP supply side effect
Labor Productivity growth, DPDTY, total effect


0,00
-2,00
-4,00
-6,00
-8,00
-10,00
-12,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Unit Capital-Labor Cost, CKL, no TFP supply side effect
Unit Capital-Labor Cost, CKL, total effect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2,00
1,50
1,00
0,50
0,00
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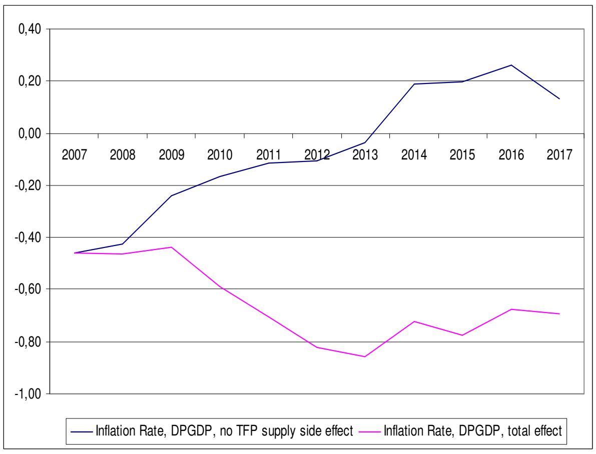
-1,50
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Unit Labor Cost, ULCB, no TFP supply side effect
Unit Labor Cost, ULCB, total effect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0,00
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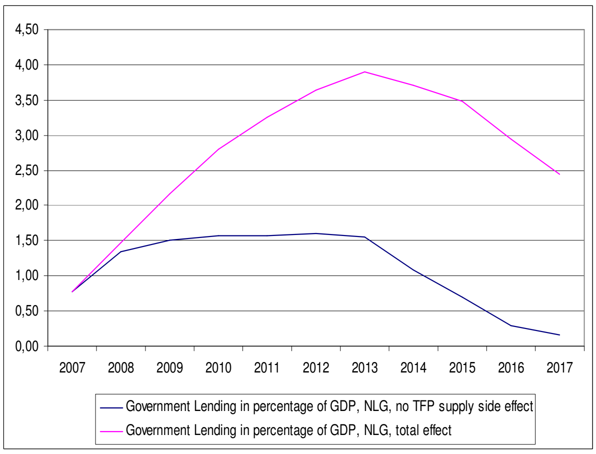
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Inflation Rate, DPGDP, no TFP supply side effect
Inflation Rate, DPGDP, total effect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3,00
2,50
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1,50
1,00
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0,00
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Government Lending in percentage of GDP, NLG, no TFP supply side effect
Government Lending in percentage of GDP, NLG, total effect