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An analysis of Naval Officer student academic performance in the Operations Analysis curriculum in relationship to academic profile codes and other factors

Blatt, Norman William.

Naval Postgraduate School: Monterey, California.

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THESIS

AN ANALYSIS OF NAVAL OFFICER STUDENT ACADEMIC PERFORMANCE IN THE OPERATIONS ANALYSIS CURRICULUM IN RELATIONSHIP TO ACADEMIC PROFILE CODES AND OTHER FACTORS

by

N. William Blatt

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20. other variables to determine their importance in explaining the OA student's academic performance. A study of 159 OA Navy OA students was completed. The analysis showed the student's overall total college grade point average, the time from completion of college to commencement of work in the OA curriculum (in fact performance does not decrease over time), the student's designator and his college degree to be the most important factors in explaining the variability of student performance.

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by

N. William Blatt
Commander, United States Navy
B.S., Oregon State University, 1968

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I. INTRODUCTION

The purpose of this thesis was to investigate various factors affecting the academic performance of Naval Officer students in the Operations Analysis Curriculum at the Naval Postgraduate School. The original goal was to arrive at a predictive model which would improve the present selection process and possibly reduce the numbers of student academic transfers out of the Operations Analysis Curriculum. These transfers have historically been about 10% of the original class. Due to the relatively small sample size (159), it was not possible to cross validate . Because of this the results are not presented as a predictive model. The utility of the study is rather in its analysis of those factors influencing the student's academic performance; the resultant promotion of understanding, and suggestions for further study of the subject.

The pertinent variables that were readily available and are in this study are college QPR, college degree, the Officer's designator, college quality rating, elapsed time from completion of college to starting the Operations Analysis Curriculum, year graduated from the OA Curriculum, and the length of refresher attended at the Naval Postgraduate School. Current practice using only the "APC" codes as a predictor achieves a multiple correlation coefficient of .21 when run through the ANOVA package. The model recommended in the study has an R^2 of .41 while another model achieves an R^2 as high as .53.

The study subjects include approximately one-half of the Navy OA graduates from the period 1974 to 1985. This was the case since APC's were only available for about one-half of the graduates. The study includes only those students

with academic profile codes of 435 or better. The recommended APC for the Operations Analysis Curriculum is 324 or better. There were 43 individuals included in the study whose APC was ,at least in one of the three digits, outside that recommended for OA. Of these 43 people, 6 went straight into the curriculum without any refresher.

A review of the literature reveals a thesis written by Heru Soetrisno in 1975 titled "Prediction of Academic Performance of the U. S. Navy Officer Students in the Operations Research/Systems Analysis curriculum at the Naval Postgraduate School" [Ref. 1]. The study was a regression analysis using biographical data, a personal interest survey and the graduate record examination. It covered all the Navy students in OA in the Spring of 1974 (72 students). The thesis concluded that the three above mentioned variables and combinations of them were better predictors of student performance than undergraduate QPR and college quality.

Numerous articles have also been written concerning the subject of predicting academic performance. A review of many of these articles has left the author with the impression that it is clearly not a clean-cut issue as to what test or measure is the best in predicting academic performance. However of all the choices, it is recognized that prior academic performance and aptitude tests are generally considered to the most important predictors of future academic performance [Ref. 2: page 10].

The study opens with the development of the academic profile code and a review of the data. The analysis is conducted by first a preliminary look at the independent variables in relationship to the dependent variable and then with an analysis of variance technique. The study ends with several conclusions and recommendations for future consideration.

II. BACKGROUND

The Navy Military Personnel Command (NMPC) is responsible for filling quotas at the Naval Posgraduate School. The current procedure is to convene annually a Graduate Selection Board [Ref. 3]. This board meets and reviews those Officer's records who are potentially eligible for graduate education as shown in enclosure four of [Ref. 3]. The board bases their determination for possible graduate education on the Officer's professional performance and their academic ability as evidenced by their academic profile code (APC) [Ref. 4]. The most recent board screened 13,000 records and selected 4,000 for possible graduate studies. Approximately 90% of those students eventually completing fully funded graduate studies will receive their degrees from the Naval Postgraduate School [Ref. 5: page 25].

The APC is a three digit code summarizing the previous education of each Officer and is calculated as seen in Figure 2.1 .

Appendix B is a sample academic record evaluation (ARE) sheet. The ARE is used by the director of admissions at the Naval Postgraduate School as a worksheet to compute an APC for every newly designated Naval Officer each year. The ARE is filed and maintained at the Director of Admission's office at the Naval Postgraduate School and is kept on file until the Officer has been designated as a subspecialist or has been determined not suitable for graduate education. NMPC annually directs the Naval Postgraduate School to remove and destroy the ARE's for those above mentioned Officers.

QPR CODE
(1st APC Digit)

Code #	Grade	QPR Range
0	A-/A	3.60 - 4.00
1	B+	3.20 - 3.59
2	B-/B	2.60 - 3.19
3	C+	2.20 - 2.59
4	C	1.90 - 2.19
5	Below C	0.00 - 1.89

(Repeated courses and failures are included in the QPR calculation.)

MATH CODE
(2nd APC Digit)

Code #	Calculus-Related Math Courses
0	Significant post-calculus math with B average
1	Two or more calculus courses with B+ average
2	Two or more calculus courses with C+ average
3	One calculus course with C grade or better
4	Two or more pre-calculus courses with B average or better
5	At least one pre-calculus course with C grade
6	No college-level math with C grade

TECHNICAL CODE
(3rd APC Digit)

Code #	Physics (Calculus-Based)	Significant Upper-Division Course Coverage in a Pertinent Engineering or Physical Science Discipline
0	----------→	B+ average
1	----------→	C+ average
2	Complete sequence taken with B+ average	
3	Complete sequence taken with C+ average	
4	At least one course with C grade	
5	None	

Figure 2.1 Calculating APC's.

The APC is originally based on the individual's college performance and rarely changes unless the individual corresponds with the Director of Admissions at the Naval Postgraduate School and petitions to raise (improve) his APC with written proof of additional accredited academic achievement [Ref. 4: page 11].

A Naval Officer must possess an APC of 324 or better (e.g. 112) to directly enter the Operations Analysis Curriculum [Ref. 5: page 32]. Additionally, a Naval Officer may enter the OA Curriculum with an APC of 344 after completing one or two quarters of the Engineering Science Curriculum. The Engineering Science Curriculum is designed to provide an opportunity for Officers with inadequate mathematical and physical science backgrounds to establish a good math foundation to be able to qualify for a technical curriculum [Ref. 5: page 36]. There is also a six week refresher available that is designed to rapidly cover the calculus and physics fundamentals for those Officers who are direct inputs into the OA curriculum without any quarters of Engineering Science. Exceptions are made and it is possible for an individual to enter the OA curriculum without the minimum APC. It is also possible for an Officer to start OA without any refresher at all as did 63 of the study subjects.

The OA curriculum is of a technical nature and students with solid college performance and technical majors are encouraged to enroll in it. However, there are some very good professional Officers who do not have the required academic background to directly enroll in OA. The Navy would like some of these Officers to be able to attend NPS in a technical curriculum . In response to this need, the Navy has recently introduced (1985) the Technical Transition Program (TTP). This program is designed to allow those professionally exceptional Officers with weak college

backgrounds to enter a technical curriculum via a one or two quarter individually tailored preparation program. This program is slightly different from the Engineering Science curriculum in that it is individually structured to meet each student's needs while it also varies from different curriculum to curriculum. This program not only provides an opportunity to Officers that at one time had no or little hope of attending the Naval Postgraduate School but it also provides more graduate trained subspecialists for the Navy.

The college records of these candidates for the TTP are screened at the Naval Postgraduate School and a decision is made whether or not to allow an individual to start the program in hopes of eventually entering a technical curriculum. This study reveals several important factors and considerations in order to help the decision maker better access the potential academic performance of future OA students.

III. DISCUSSION OF THE DATA

The study data was gathered from several sources including the Office of the Registrar, Director of Admissions, the Operations Analysis Curricular office at the Naval Postgraduate School and from the Naval Military Personnel Command. Most of the data was obtained from the individual student files maintained by the Operations Analysis curriculum secretary. These files contained much of the student data such as University attended and what dates attended, college degree, designator and length of refresher attended at the Naval Postgraduate school. These same files contain the student's grade sheet summary of all course work completed at the Naval Postgradute School. From this sheet, the dependent variable in the study was calculated. Four different quality point ratings (QPR) were studied. The first was the student's total grade average after four quarters of the Operations Analysis Curriculum. This grade is of special importance as it is at this point in the curriculum that a final decision must be made as to continue a marginally performing student in hopes that his overall grade point average will improve or to allow him to possibly transfer to another curriculum with enough time remaining to successfully complete that program. It is also important to note that through the first four quarters each option is essentially the same. Hence, there is uniformity in the program. If a model could be constructed that would improve the present selection process and reduce the numbers of these transfers, a savings in time and money could be realized by the Navy.

The three other dependent variables looked at were the student's quality point rating after six quarters (when most

of the stringent course requirements are finished), his graduate qpr after eight quarters and also the total overall quality point rating after eight quarters which completes the degree. All these qpr's were determined by dividing the weighted total of the grade points earned by the total hours attempted for the respective quarter totals. None of these qpr's included any grades earned during refresher courses.

The academic profile codes were the most difficult data points to obtain. Although the Director of Admissions maintains a computer printout of all current APC's, very few of the study subjects were still on the listing. Of the 343 Navy CA students completing the Operations Analysis curriculum at the Naval Postgraduate School from 1974 to 1985, only 80 of them had APC's in the printout, in their files or in their academic record evaluation sheets. The additional APC's were obtained from the Officer's data card sent to the Naval Postgraduate School by NMPC. A total of 172 APC's were obtained. Of these 172 APC's, 159 were used in the study. The thirteen individuals removed from the study were in very low populated levels of several of the variables. The variables for the academic profile codes are seen in Figure 3.1 .

The 159 Naval Officer study subjects all graduated with Master Degrees in Operations Analysis. Although not a random sample, they were treated as a random sample for the purpose of the study. There was no apparent grouping or special distribution of the study subjects compared to the entire population of 343. The data were tabulated into an 159 by 18 matrix and is included as Appendix C.

The variable college rating was obtained from the Gourman Report [Ref. 6: page 7]. This report evaluated 1,845 colleges and universities in terms of the institution's objectives, curriculum, faculty, faculty research and honors, administration, library, budget, resources, student

APC1 = College QPR

code	main effect level	# of data points
0	1	8
1	2	28
2	3	79
3	4	39
4	5	5
	total	159

APC2 = Math Code

code	main effect level	# of data points
0	1	24
1	2	29
2	3	76
3	4	30
	total	159

APC3 = Technical Code

code	main effect level	# of data points
0	1	4
1	2	19
2	3	25
3	4	59
4	5	39
5	6	13
	total	159

Figure 3.1 APC Main Effects.

scores on standardized tests, admission policy, and several other factors. The range for the college rating variable as

a cofactor was 4.99 for the highest rated institution down to a rating of 2.01 for the lowest. This variable was also looked at as a possible main effect and was divided into categories as seen in Figure 3.2 .

rating	range	level	# of data points
strong	4.41-4.99	6	34
good	4.01-4.40	5	85
acceptable	3.51-3.99	4	18
adequate	3.01-3.50	3	19
marginal	2.01-2.99	2	3
		total	159

Figure 3.2 College Rating.

The variable college degree is seen in Figure 3.3 . The grouping Naval Science was required due to the twelve students included in the study who graduated from the Naval Academy prior to 1973. Prior to that time only one degree was confirmed by the institution and although the midshipmen took a variety of courses, many of which were of an engineering nature, they received a B.S. degree in Naval Science.

The variable refresher was investigated as both a main effect (yes=attended or no=did not attend) and as a cofactor listing the length, in quarters, of refresher taken at the Naval Postgraduate School. There is a six week refresher for each class prior to starting the curriculum. Additionally, a student may possibly receive one or two quarters of refresher depending on several factors. These quarters of refresher are generally undertaken by students

Degree	level	# of data points
Business	1	14
Engineering	2	31
Humanities	3	4
Math	4	59
Social Science	5	16
Naval Science	6	12
Operations Analysis	7	23
	total	159

Figure 3.3 College Degree.

not meeting the minimum recommended APC for OA or for students who have not been in an academic environment for a long period of time. The decision is generally made at the Curricular Officer and Academic Associate's concurrence and with approval from the student's detailer. There is nothing concrete about this process and it is possible to start the curriculum directly without any refresher. The cofactor length of refresher was grouped as seen in Figure 3.4 .

The variable designator was viewed as a main effect. Each Naval Officer has one designator which is generally assigned after completing a school or training course. They retain this designator for their entire length of service with the few exceptions of individuals transfering to another specialty and hence changing designators. The designators of the study group can be seen in Figure 3.5 .

Table I is a summary listing of all the variables and their levels that were investigated in the study.

quarters of Refresher	level	# of data points
0	1	63
.5	2	58
1	3	8
2	4	30
	total	159

Figure 3.4 Length of Refresher.

designator	definition	level	# of data pts.
110x	restricted line	1	6
111x	unrestricted line	2	50
112x	submarines	3	10
131x	aviator	4	41
132x	naval flight officer	5	26
140x	engineering duty	6	1
161x	intelligence	7	3
310x	supply	8	20
113x	special warfare	9	2
		total	159

Figure 3.5 Designator.

TABLE I

EXPLANATION OF THE STUDY'S VARIABLES

Cofactors		Values
time since college in months		23-178
college rating		2.01-4.99
year graduated from NPS		74-85
length of refresher (quarters)		0, .5, 1, 2
Main Effects		**Level**
APC1	college qpr *	1,2,3,4,5
APC2	math code *	1,2,3,4
APC3	technical code *	1,2,3,4,5,6
College Degree		**Level**
Business		1
Engineering		2
Humanities		3
Natural Science (Math)		4
Social Science		5
Naval Science		6
Operations Analysis		7
Designator		**Level**
110x	Restricted line	1
111x	Unrestricted line	2
112x	Submarines	3
131x	Aviator	4
132x	Naval flight officer	5
140x	Engineering Duty officer	6
161x	Intelligence officer	7
310x	Supply officer	8
113x	Special Warfare officer	9

* Coded as APC + 1 for computer indexing

IV. PRELIMINARY ANALYSIS OF THE DATA

A preliminary analysis of the data was conducted using APL and Grafstat capabilities of the IBM 370 located at the Naval Postgraduate School. Each variable was investigated in relation to the dependent variable "4th quarter qpr". All remarks of significant differences are a result of a formal "t" test with a .05 level of significance.

A. 4TH QUARTER QPR VERSUS APC1

The first APC digit representing the individual's overall college qpr was plotted against his academic performance in the OA curriculum through the fourth quarter.

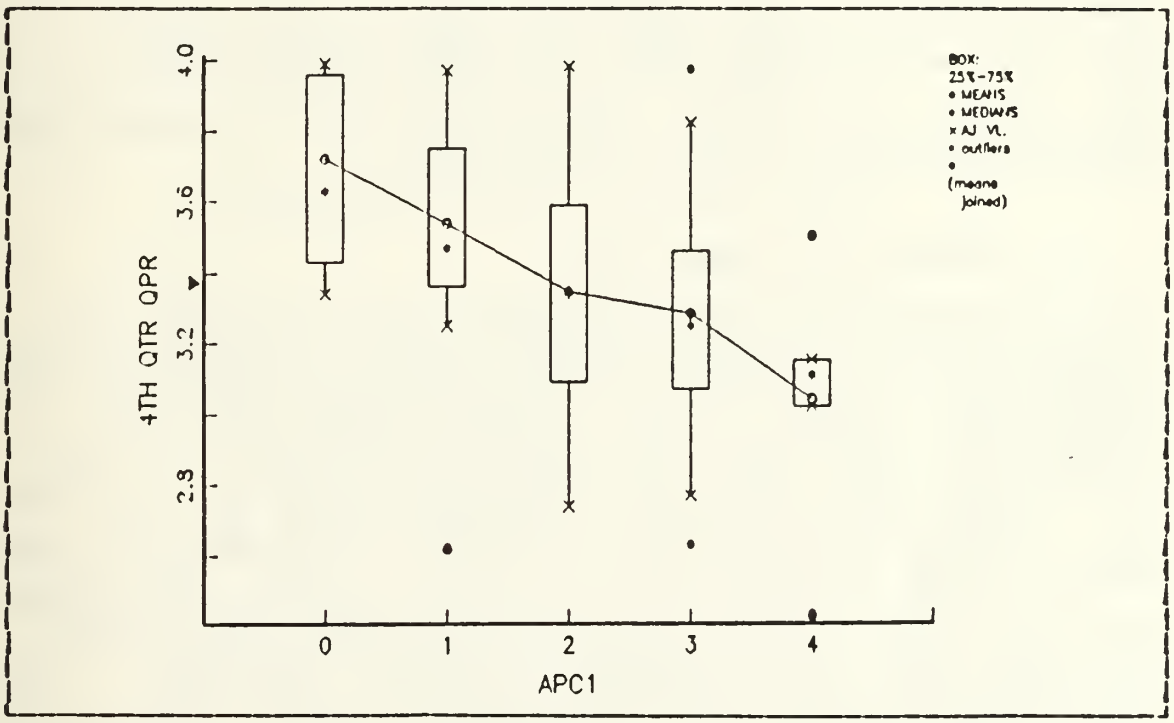


Figure 4.1 4th QTR QPR VS APC1.

Figure 4.1 is a graphical representation of the statistical relationship while the results are tabulated in Table II.

TABLE II

4th QTR QPR VS APC1

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
0	8	0.050314	3.72	0.24068	3.43	3.63	3.96
1	28	0.1761	3.5386	0.27132	3.36	3.47	3.75
2	79	0.49686	3.3448	0.3088	3.09	3.34	3.59
3	39	0.24528	3.2826	0.32053	3.07	3.25	3.46
4	5	0.031447	3.042	0.34672	3.02	3.11	3.15

These results show the student's performance in college has a direct and logical relationship to his performance through the fourth quarter of the OA curriculum. The higher one's college qpr the better one's performance in OA. The study group's average APC for the first digit is very close to two while the overall grand mean for their fourth quarter grade was 3.37. The highest code of zero had a significant difference compared to the overall mean.

B. 4TH QUARTER QPR VERSUS APC2

The second APC digit representing the student's undergraduate calculus proficiency was plotted against his 4th quarter qpr. Figure 4.2 is a representation of this relationship and the numerical results are tabulated in Table III. There is a significant difference among the first two levels of this variable and the overall mean. The recommended APC for OA in math is three or better while four is acceptable via the engineering science curriculum. The study group's average was 1.7 while the entire group had a math APC of three or better. The overall relationship is

just a slight positive one where the lower (better) one's math code translates to a higher 4th quarter grade.

C. 4TH QUARTER QPR VERSUS APC3

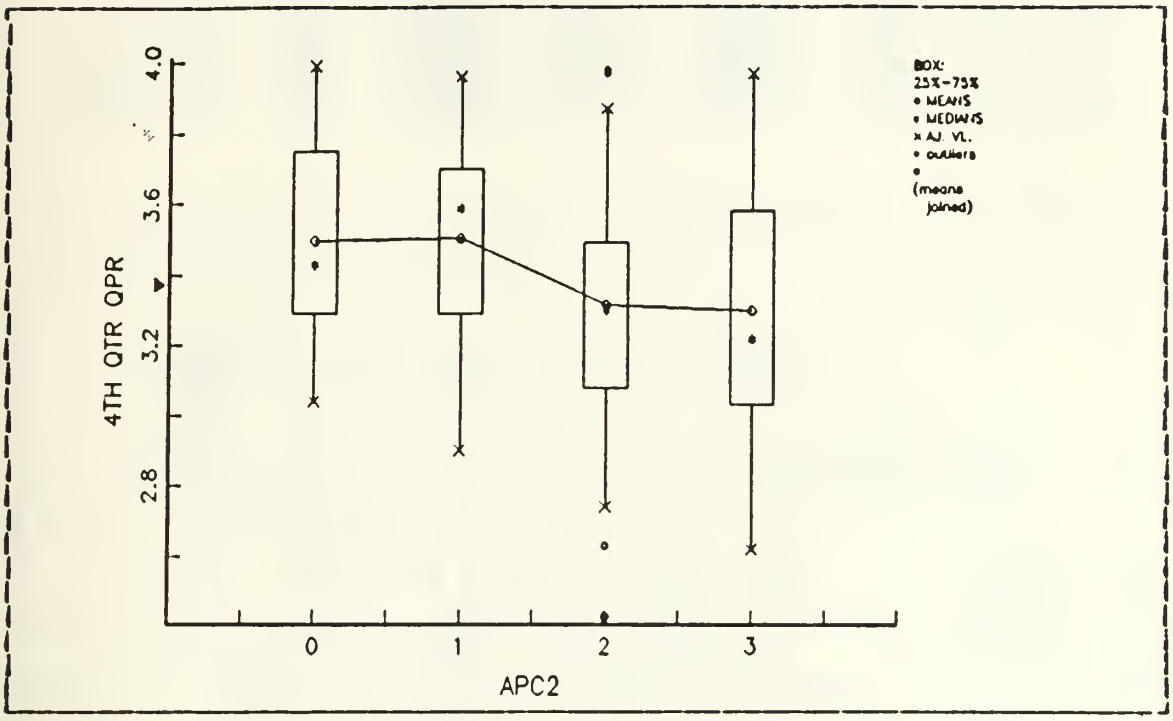


Figure 4.2 4th QTR QPR VS APC2.

The third APC digit representing the student's technical code was similary studied and is shown Figure 4.3 and Table IV. This relationship does not show a logical progression of high 4th quarter performance with the better technical codes. It in fact jumps back and forth with no apparent logic. Admission to the OA curriculum may reflect some compensating feature.

The last level (those students with an APC3 code of five) of thirteen individuals had the second best average qpr. These thirteen subjects were looked at individually to

TABLE III

4TH QTR QPR VS APC2

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
0	24	0.15094	3.4963	0.26836	3.29	3.43	3.75
1	29	0.18239	3.5034	0.2918	3.29	3.59	3.7
2	76	0.47799	3.3143	0.32307	3.08	3.3	3.49
3	30	0.18868	3.297	0.3607	3.03	3.22	3.58

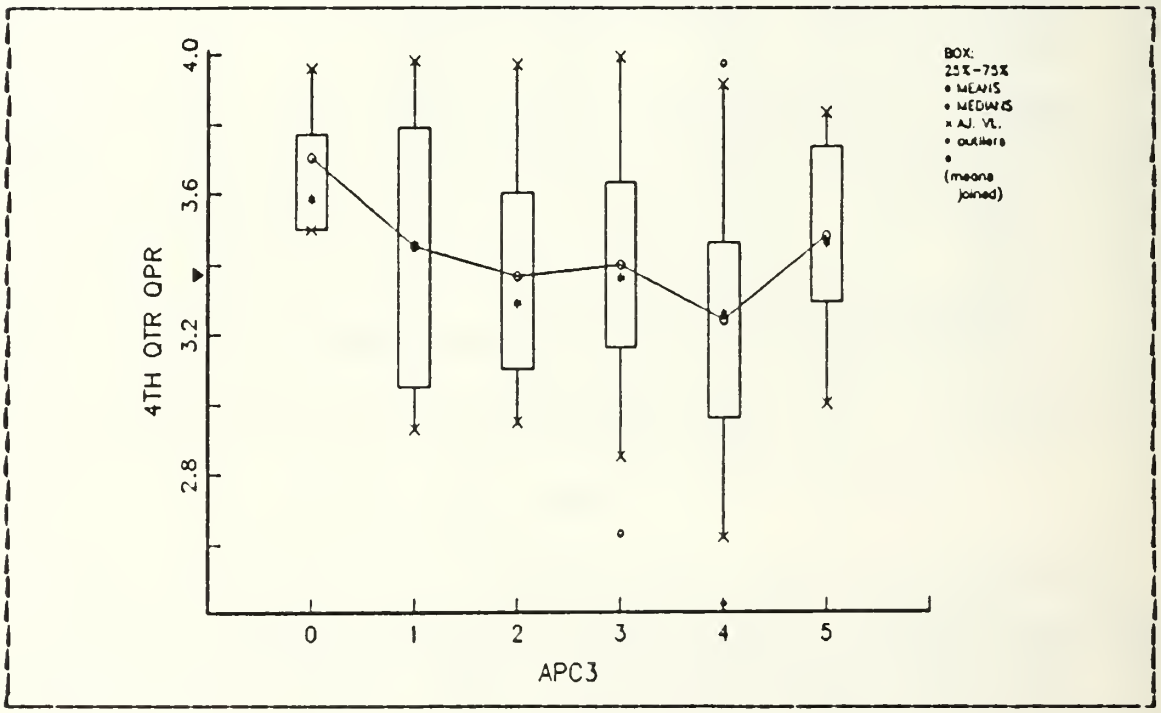


Figure 4.3 4th QTR QPR VS APC3.

try to determine a possible reason for this. It was discovered, that as a group, their average first digit APC for their college performance was 1.4. This is much better than the entire study group's average of 2.1. The only differences between the six level means and the overall mean that

TABLE IV

4TH QTR QPR VS APC3

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
0	4	0.025157	3.705	0.17642	3.5	3.59	3.77
1	19	0.1195	3.4511	0.33468	3.05	3.46	3.79
2	25	0.15723	3.3636	0.29094	3.1	3.29	3.6
3	59	0.37107	3.3958	0.29821	3.16	3.36	3.63
4	39	0.24528	3.2379	0.3671	3.96	3.26	3.46
5	13	0.081761	3.4769	0.27921	3.29	3.46	3.73

were statistically significant were the first level zero and the next to last level four.

D. 4TH QUARTER QPR VERSUS COLLEGE DEGREE

Ccllege degree was the next variable plotted against the 4th quarter qpr. Figure 4.4 graphically presents and Table V lists this data.

Although none of the differences are statistically significant, the business, engineering, math and operations analysis majors performed above the mean of the study sample. If one disregards an outlier or two within the OA level, OA would have shown a greater positive difference from the grand mean and this can be seen in its inter-quartile range. The data shows an intuitively logical assumption that students with a social science or humanities undergraduate degree would do less well in a technical curriculum when compared to students with a more quantitative college degree such as engineering or mathematics. The performance of those people with naval science majors is relatively low. This may be a result of several confounding factors not readily apparent.

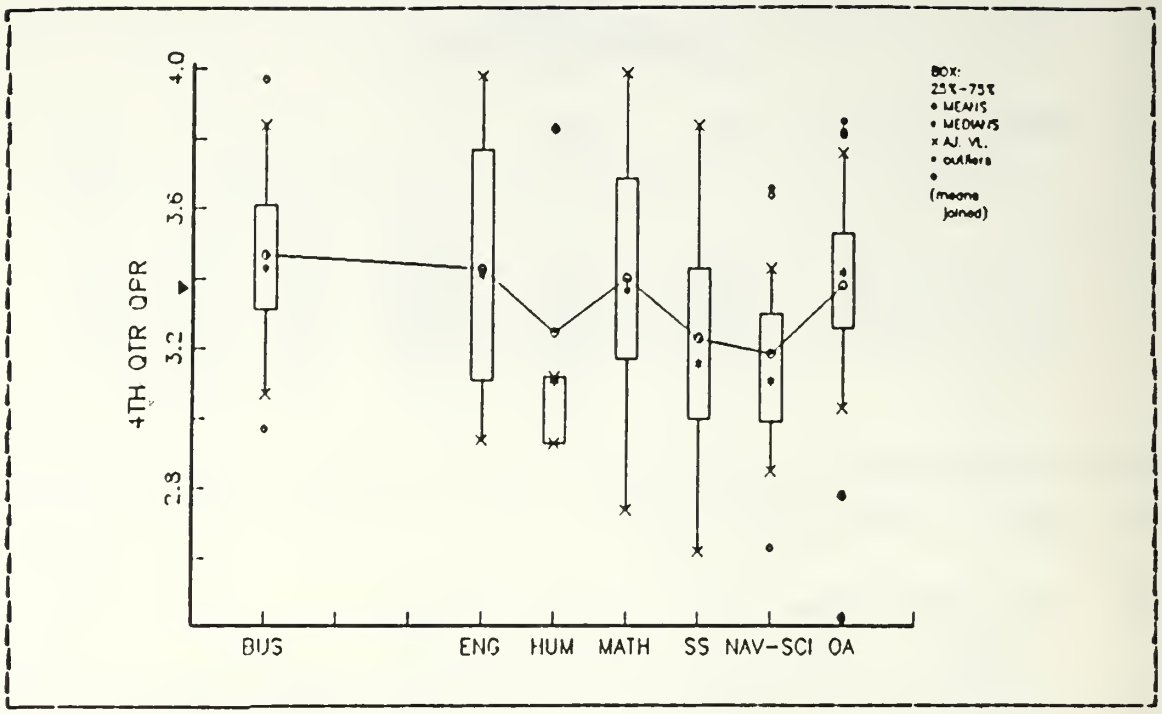


Figure 4.4 4th QTR QPR VS College Degree.

TABLE V

4TH QTR QPR VS COLLEGE DEGREE

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
BUSINESS	14	0.08805	3.4657	0.30352	3.31	3.43	3.61
ENGINEERING	31	0.19497	3.4274	0.32373	3.11	3.41	3.77
HUMANITIES	4	0.025157	3.2475	0.3447	2.93	3.11	3.12
MATH	59	0.37107	3.4037	0.31953	3.17	3.37	3.69
SOCIAL SCI	16	0.10063	3.2306	0.32225	3	3.16	3.43
NAVAL SCI	12	0.075472	3.1875	0.28902	2.99	3.11	3.3
OA	23	0.14465	3.3822	0.33327	3.26	3.42	3.53

E. 4TH QUARTER QPR VERSUS DESIGNATOR

The student's designator was the next variable plotted against 4th quarter qpr. Disregarding the very small levels of 1400, 1610, and 1130 from the discussion, leaves only

1120 (submariners), 1320 (naval flight officers) and 3100 (supply) designators that did better than the grand mean. This can be seen in Figure 4.5 and Table VI. A test of significance showed only the 1120 and 3100 designators performed better and the 1100 designator performed worse than the overall mean.

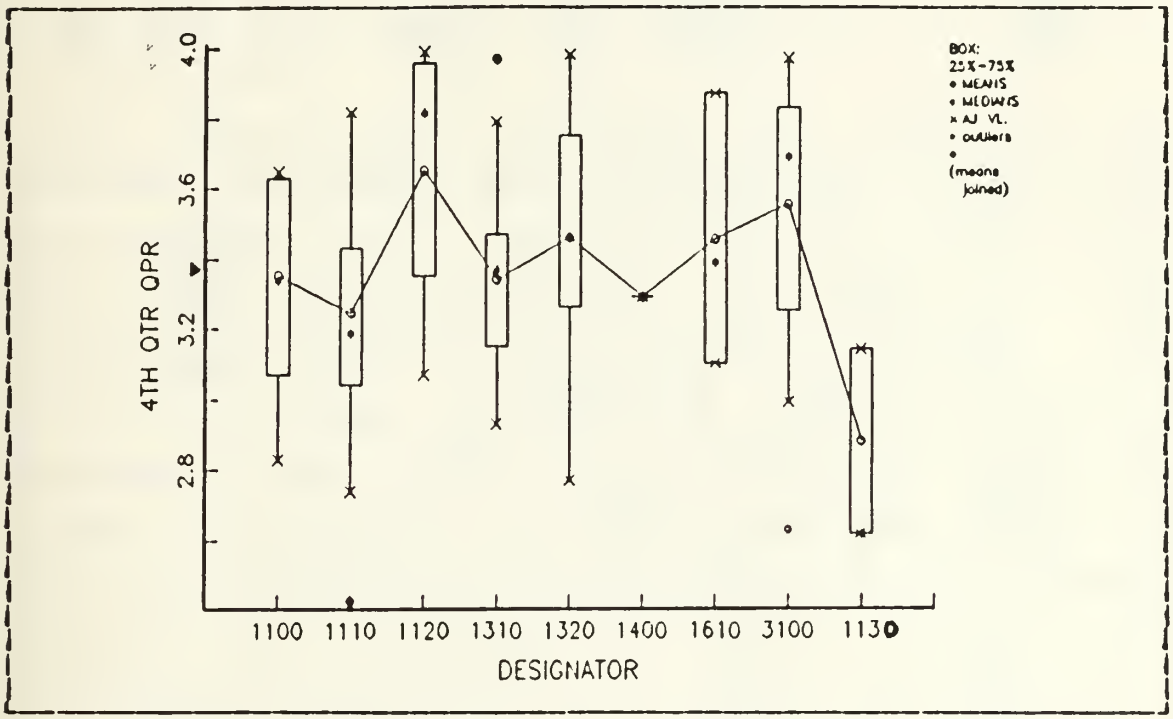


Figure 4.5 4th QTR QPR VS Designator.

F. 4TH QUARTER QPR VERSUS LENGTH OF REFRESHER

The variable length of refresher was plotted against 4th quarter qpr as seen in Figure 4.6 and Table VII.

It can be seen that those individuals who do not attend refresher do slightly better than the students that attend refresher. This could mean that a good job is done identifying those individuals who need refresher. It is also

TABLE VI

4TH QTR QPR VS DESIGNATOR

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
1100	6	0.037736	3.3517	0.30954	3.07	3.34	3.63
1110	50	0.31447	3.2456	0.31481	3.04	3.19	3.43
1120	10	0.062893	3.654	0.32855	3.35	3.82	3.96
1310	41	0.25786	3.341	0.23245	3.15	3.37	3.47
1320	26	0.16352	3.4588	0.31471	3.26	3.46	3.75
1400	1	0.0062893	3.29	0	3.29	3.29	3.29
1610	3	0.018868	3.4533	0.31753	3.1	3.39	3.87
3100	20	0.12579	3.553	0.35289	3.25	3.69	3.83
1130	2	0.012579	2.88	0.26	2.62	2.62	3.14

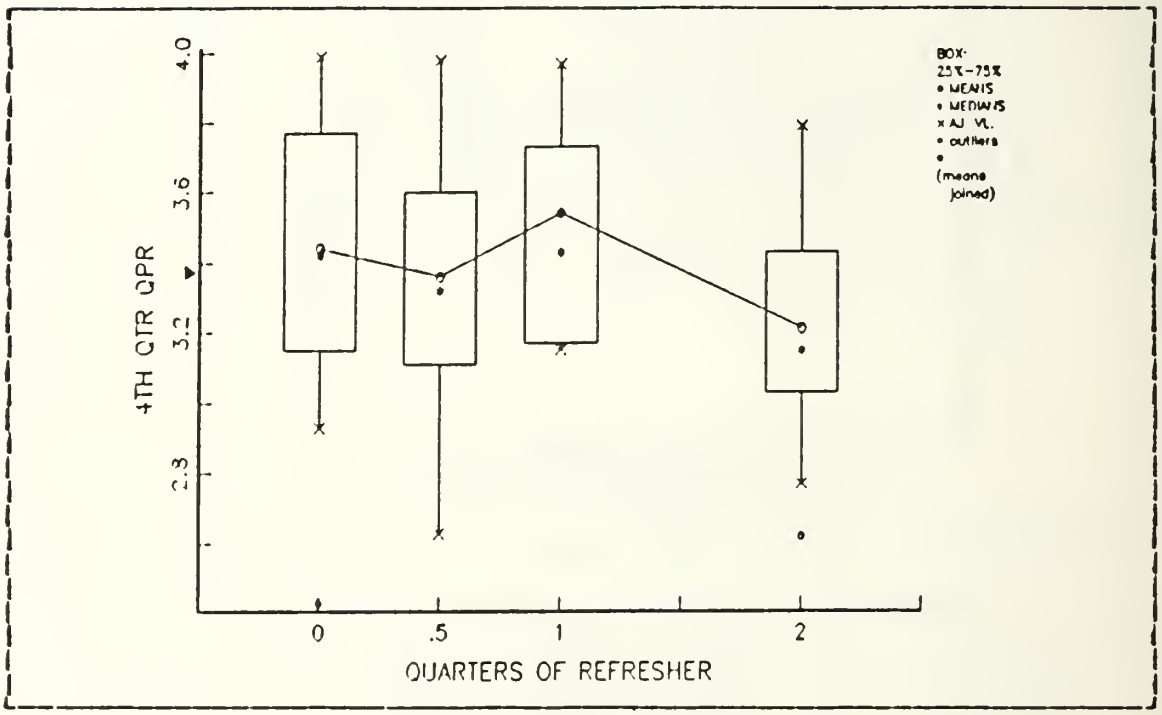


Figure 4.6 4th QTR QPR VS Length of Refresher.

possible that the students themselves have an influence in whether or not they attend refresher. It could also be that those students that have a very confident opinion of their academic background may be deliberately deciding not to report until well after refresher starts. This sort of

TABLE VII

4TH QTR QPR VS LENGTH OF REFRESHER

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
0	63	0.39623	3.441	0.33443	3.15	3.42	3.77
0.5	58	0.36478	3.3597	0.32014	3.11	3.32	3.6
1	8	0.050314	3.54	0.29039	3.17	3.43	3.73
2	30	0.18868	3.2117	0.28024	3.03	3.15	3.43

biased selection could be affecting the results of this variable. The result of the students with one quarter of refresher doing better than the mean could also be artificial. Once they demonstrated that even though they fit the category of individuals who should get refresher, they really could handle the pace without it then they could be set back into their original class with a few scheduling arrangements made. There is also no permanent incentive to do well in the 460 curriculum since the grades do not count and are not reflected in the student's total grade average. The formal test of significance showed that only the students with two quarters of refresher performed at a statistically lower level than the overall grand mean.

G. 4TH QUARTER QPR VERSUS COLLEGE RATING

The variable college rating was the next variable plotted against 4th quarter qpr and is shown in Figure 4.7 and Table VIII. The data does not show a significant difference among any of the college ratings. Disregard the lowest rating as it only contains three individuals. The remaining four categories show a slight decrease in 4th quarter qpr as the rating decreases but it is not statistically significant.

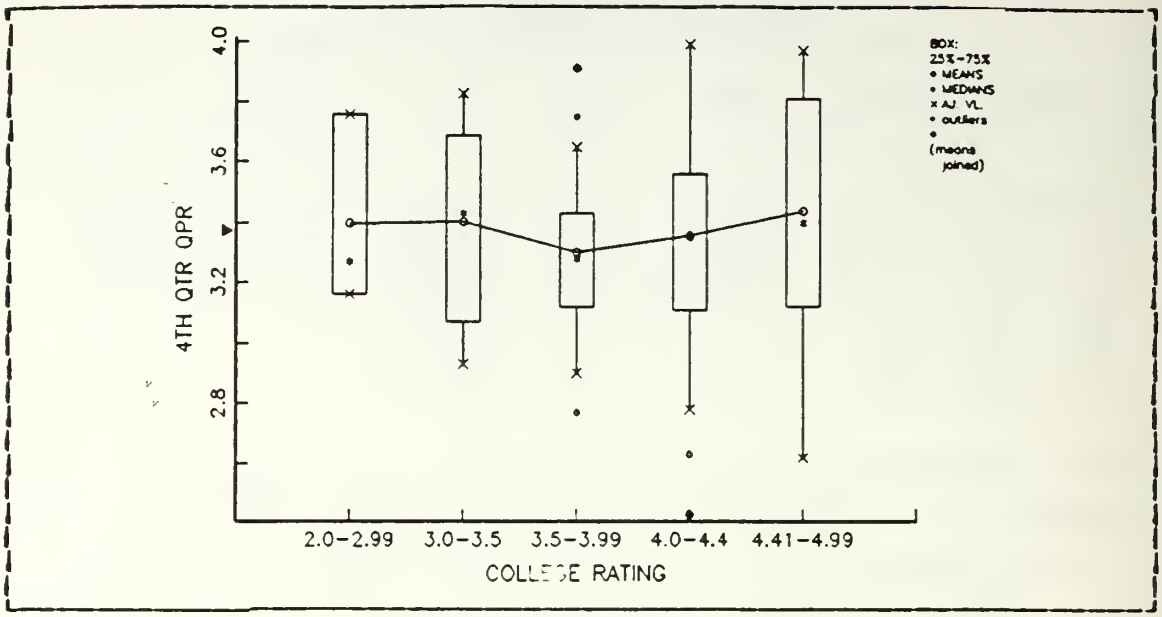


Figure 4.7 4th Qtr QPR VS College Rating.

TABLE VIII

4TH QUARTER QPR VERSUS COLLEGE RATING

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
2.0-2.99	3	0.018868	3.3967	0.26081	3.16	3.27	3.76
3.0-3.5	19	0.1195	3.4005	0.29915	3.07	3.43	3.69
3.5-3.99	18	0.11321	3.3	0.28746	3.12	3.28	3.43
4.0-4.4	85	0.53459	3.3554	0.32538	3.11	3.35	3.56
4.41-4.99	34	0.21384	3.4382	0.36992	3.12	3.4	3.81

H. 4TH QUARTER QPR VERSUS YEAR GRADUATED FROM NPS

The variable year graduated from NPS was plotted against 4th quarter qpr and is seen in Figure 4.8 and Table IX. The data is seen to be heavily concentrated in the three most recent years (46% of all study subjects). The years 74 and 75 showed a statistically significant mean that was below

the overall mean of 3.37. The year 1980 was the only year that was significantly above the overall average. This could possibly reflect the "luck of the draw" as different student sections progress through the curriculum with different combinations of professors and grading practices.

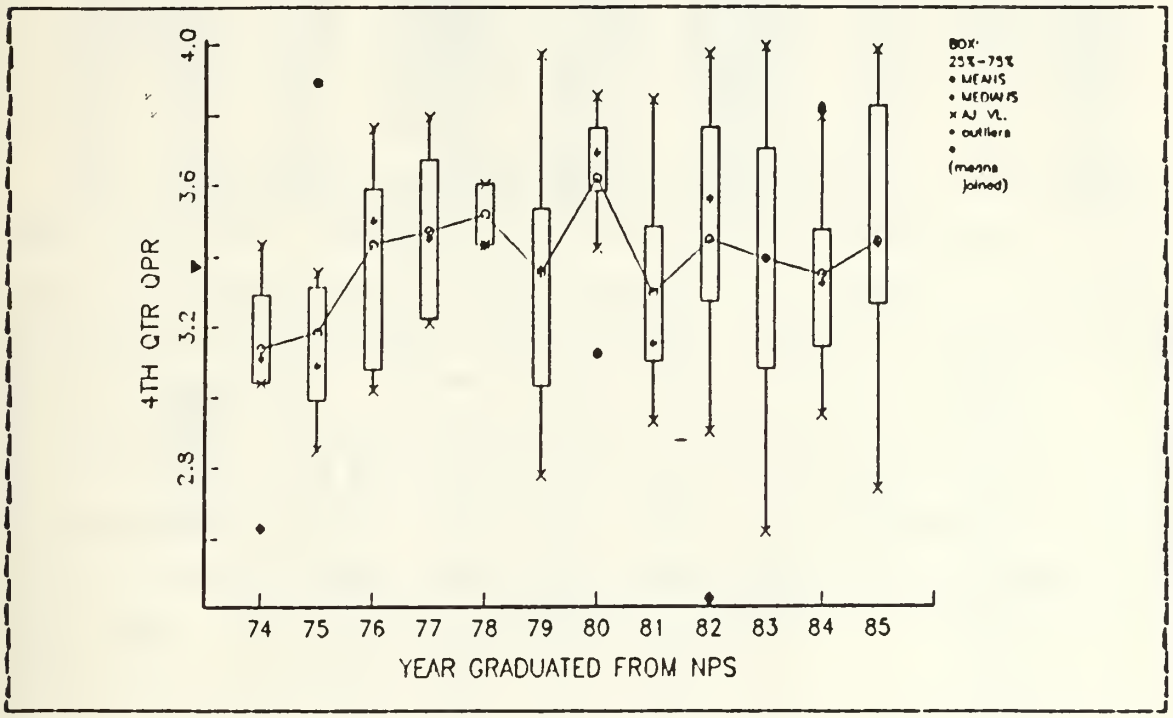


Figure 4.8 4th QTR QPR VS Year Graduated from NPS.

I. 4TH QUARTER QPR VERSUS TIME SINCE COLLEGE

The variable time since college was plotted against the 4th quarter qpr as seen in Figure 4.9 and Table X.
After discarding the first level with only two observations, it is of interest to note the very slight improvement in qpr as time since college increases. Once again the differences between the overall mean and the individual level means are not significant in a formal test of significance. The

TABLE IX

4TH QUARTER QPR VERSUS YEAR GRADUATED FROM NPS

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
1974	8	0.050314	3.1388	0.24174	3.04	3.11	3.29
1975	12	0.075472	3.1825	0.25898	2.99	3.09	3.31
1976	7	0.044025	3.4314	0.25525	3.08	3.5	3.59
1977	7	0.044025	3.47	0.21024	3.22	3.45	3.67
1978	2	0.012579	3.515	0.085	3.43	3.43	3.6
1979	14	0.08805	3.3514	0.33939	3.03	3.36	3.53
1980	9	0.056604	3.6178	0.21186	3.58	3.69	3.76
1981	11	0.069182	3.2918	0.28074	3.1	3.15	3.48
1982	15	0.09434	3.4433	0.39383	3.27	3.56	3.76
1983	31	0.19497	3.3881	0.355	3.08	3.39	3.7
1984	27	0.16981	3.3441	0.2765	3.14	3.32	3.47
1985	16	0.10063	3.4381	0.37902	3.26	3.43	3.82

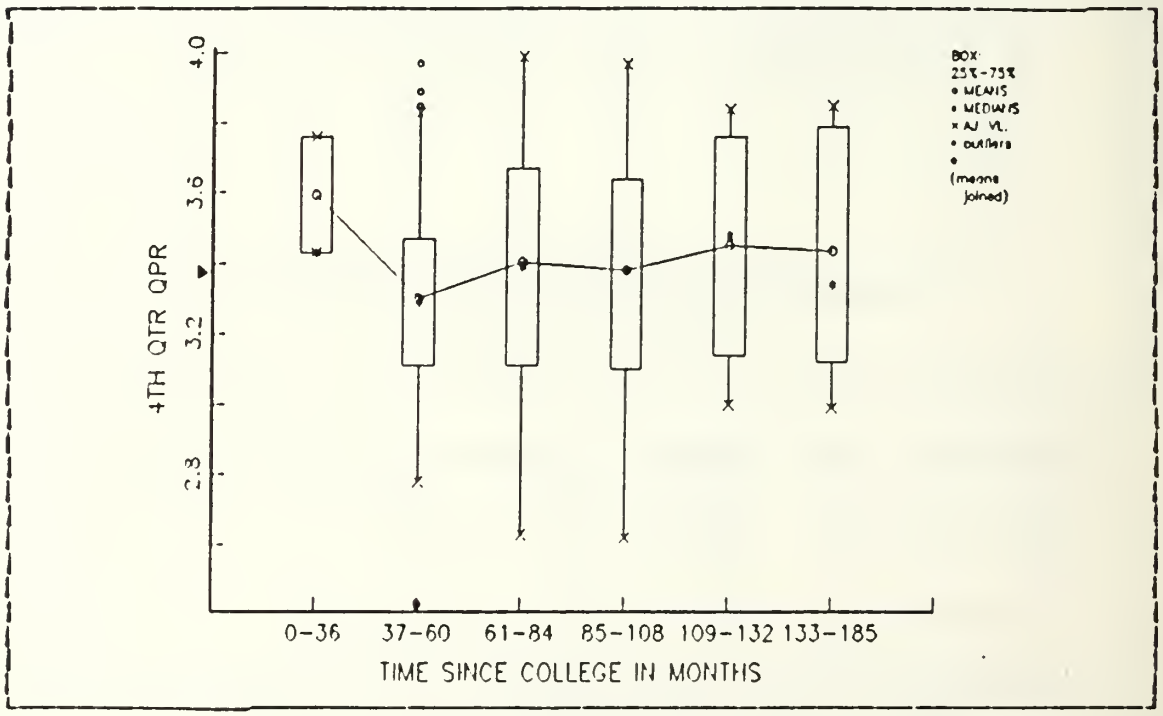


Figure 4.9 4th Quarter QPR Vs Time Since College.

relative constant performance over this variable is surprising as one would logically expect performance to be degraded as the time since completing college and commencing another academic situation increases.

TABLE X

4TH QUARTER QPR VERSUS TIME SINCE COLLEGE

CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.373	0.33011	3.12	3.36	3.64
0-36	2	0.012579	3.595	0.165	3.43	3.43	3.76
37-60	58	0.36478	3.3	0.30956	3.11	3.29	3.47
61-84	38	0.23899	3.4037	0.34813	3.11	3.39	3.67
85-108	27	0.16981	3.38	0.35614	3.1	3.38	3.64
109-132	19	0.1195	3.4516	0.29108	3.14	3.48	3.76
133-185	15	0.09434	3.436	0.31117	3.12	3.34	3.79

The preceeding relationships were looked at to investigate the basic properties of the variables studied and not to draw conclusions on these results. It would be incorrect to draw the conclusion that these one to one comparisons imply any direct cause and effect without studying the interactions of all the variables concerned. Chapter V will investigate these relationships with an analysis of variance approach. Appendix D contains the same figures and tables for the other three dependent variables (6th quarter graduate qpr, 8th quarter graduate total qpr and 8th quarter total qpr).

V. RESULTS OF THE ANALYSIS

A. APPROACH OF THE ANALYSIS

This chapter describes the analysis techniques used and the results from the analysis. The analysis of the data was conducted with the aid of the Naval Postgraduate School's IBM 370 computer using an "ANOVA" package designed by Professor Russell Richards of the Naval Postgraduate School.

The "ANOVA" package is capable of performing multiple linear regression on unbalanced data. It is an APL program with many and varied outputs. Appendix E is an explanation of the "ANOVA" program, its capabilities and required input data format. The program uses the least squares approach and calculations are done in matrix format.

All of the 159 students that comprised the population of this study were included in the analysis to develop a model for possible prediction of student performance. A cross validation procedure, using a portion of the data, would have been a useful technique to check the validity of the results. This procedure was not employed due to the limited number of academic profile codes that were available for the study.

B. MULTIPLE LINEAR REGRESSION ANALYSIS

Multiple linear regression techniques were employed using the "ANOVA" program to develop the explanatory variables to be included in the model and then to estimate the coefficients describing the weights to assign to the variables.

C. MODEL

The model used is of the matrix form:

$$Y = XB + e \qquad \text{(eqn 5.1)}$$

where, Y is a vector of dependent variables
X is a matrix of independent variables
B is a vector of coefficients
e is a vector of error terms.

In ANOVA applications of linear models, the qualitative (main and interaction) effects are estimated on an interval scale and have arbitrary origins. Hence the matrix X is singular. The "ANOVA" package (Professor Richards) solution manages this problem by deletion of selected columns and these selected columns are listed for the user. A selected column represents an omitted variable whose estimated coefficient is the negative of the total of all other variables in its category.

D. ASSUMPTIONS FOR LINEAR REGRESSION

While using the linear regression approach, a number of assumptions must be made concerning the error terms. The errors must be independent, have zero mean, constant variance and must be normally distributed [Ref. 7]. Each time the "ANOVA" program was run on a different version of the model the residuals were plotted to verify these assumptions. Figure 5.1, Figure 5.2 and Figure 5.3 display these results for the particular model that will later be developed as the study model of choice. These figures and the discussion in the following paragraph show the assumptions are adequately met.

The variables included in the model must also be independent. The Pearson's product moment correlation

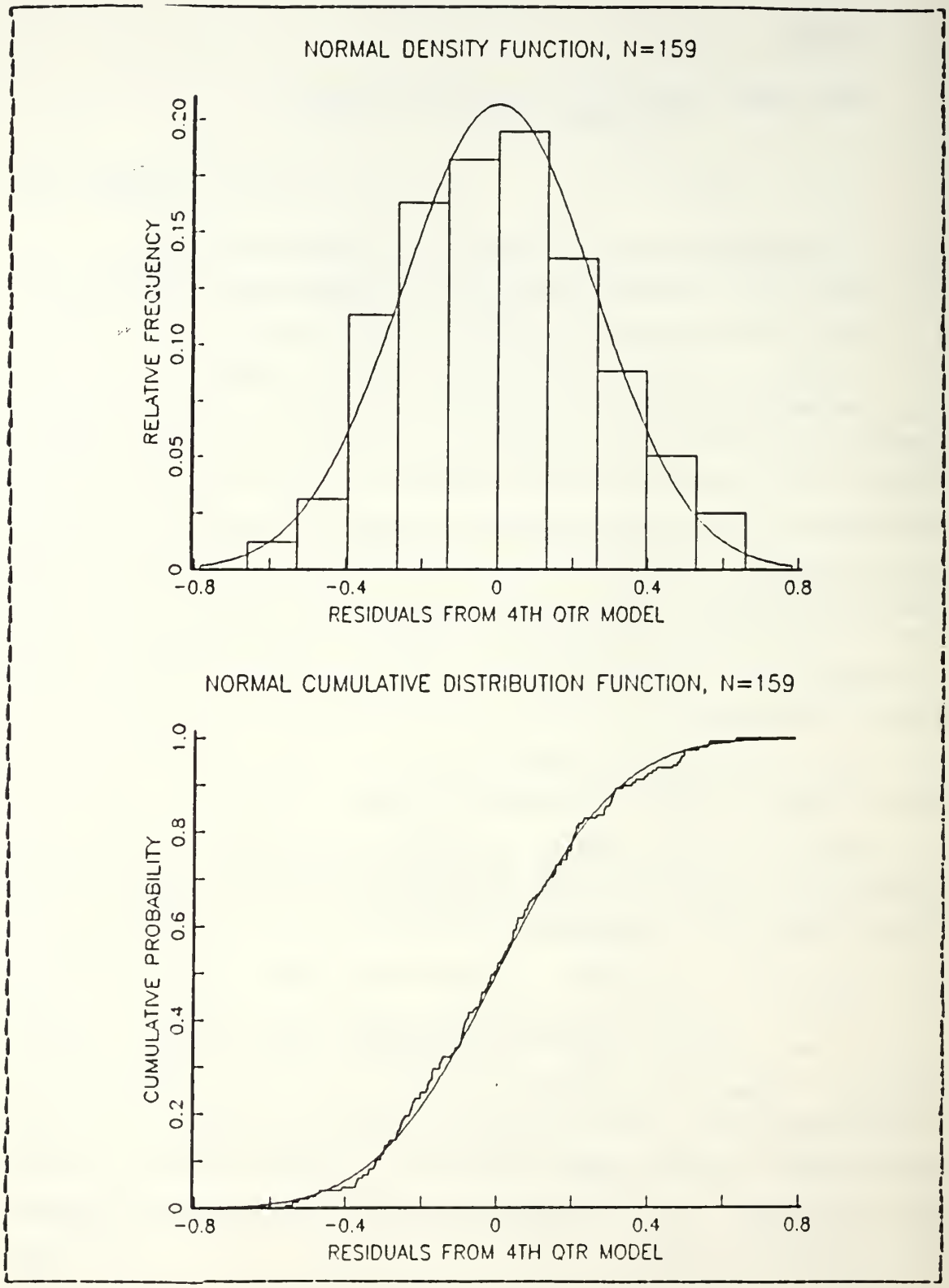
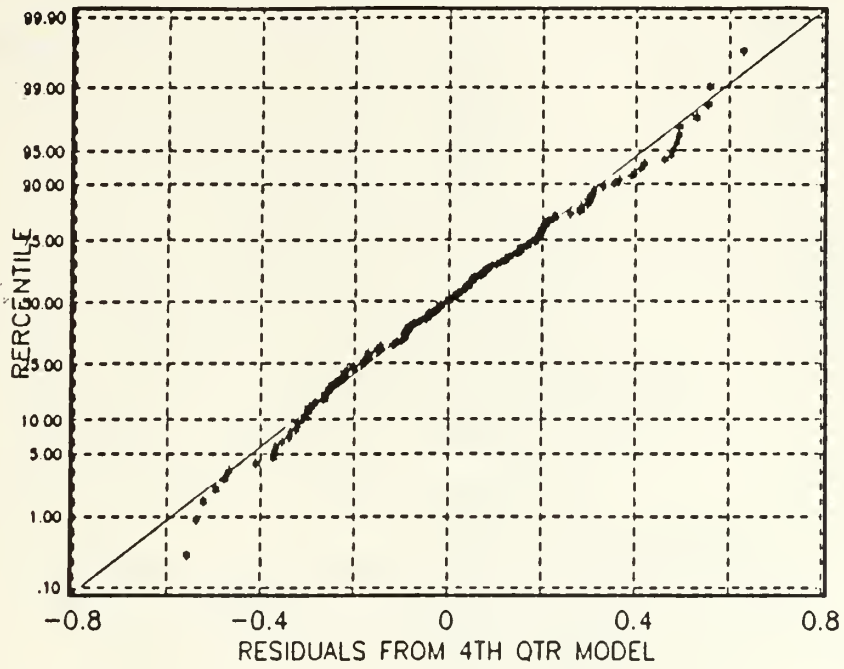


Figure 5.1 Plots of Residuals from the Study Model of Choice.



NORMAL DISTRIBUTION

X : DD
SELECTION : ALL
LABEL : RESIDUALS FROM 4TH QTR MODEL
SAMPLE SIZE: 159
MINIMUM : -.559
MAXIMUM : .629
CENSORING : NONE
EST. METHOD: MAXIMUM LIKELIHOOD

	SAMPLE	FITTED
MEAN :	1.4820E-14	1.4820E-14
STD DEV :	2.5409E-1	2.5409E-1
SKEWNESS:	1.8156E-1	0.0000E0
KURTOSIS:	2.5598E0	3.0000E0

PERCENTILES	SAMPLE	FITTED
5:	-0.37345	-4.1804E-1
10:	-0.31989	-3.2568E-1
25:	-0.18835	-1.7131E-1
50:	-0.0083107	2.5665E-8
75:	0.18291	1.7131E-1
90:	0.35343	3.2568E-1
95:	0.48034	4.1804E-1

COVARIANCE MATRIX OF PARAMETER ESTIMATES

	MU	SIGMA
MU	0.00040351	0
SIGMA	0	0.00020303

GOODNESS OF FIT

CHI-SQUARE :	2.8393
DEG FREED:	5
SIGNIF :	0.72474
KOLM-SMIRN :	0.044604
SIGNIF :	0.90979
CRAMER-V M :	0.021326
SIGNIF :	> .15
ANDER-DARL :	0.3338
SIGNIF :	> .15

KS, AD, AND CV SIGNIF. LEVELS NOT EXACT WITH ESTIMATED PARAMETERS

0.95 CONFIDENCE INTERVALS

PARAMETER	ESTIMATE	LOWER	UPPER
MU	1.4820E-14	-0.039379	0.039379
SIGMA	2.5409E-1	0.2289	0.28557

Figure 5.2 Residual Plot and Data :Study Model.

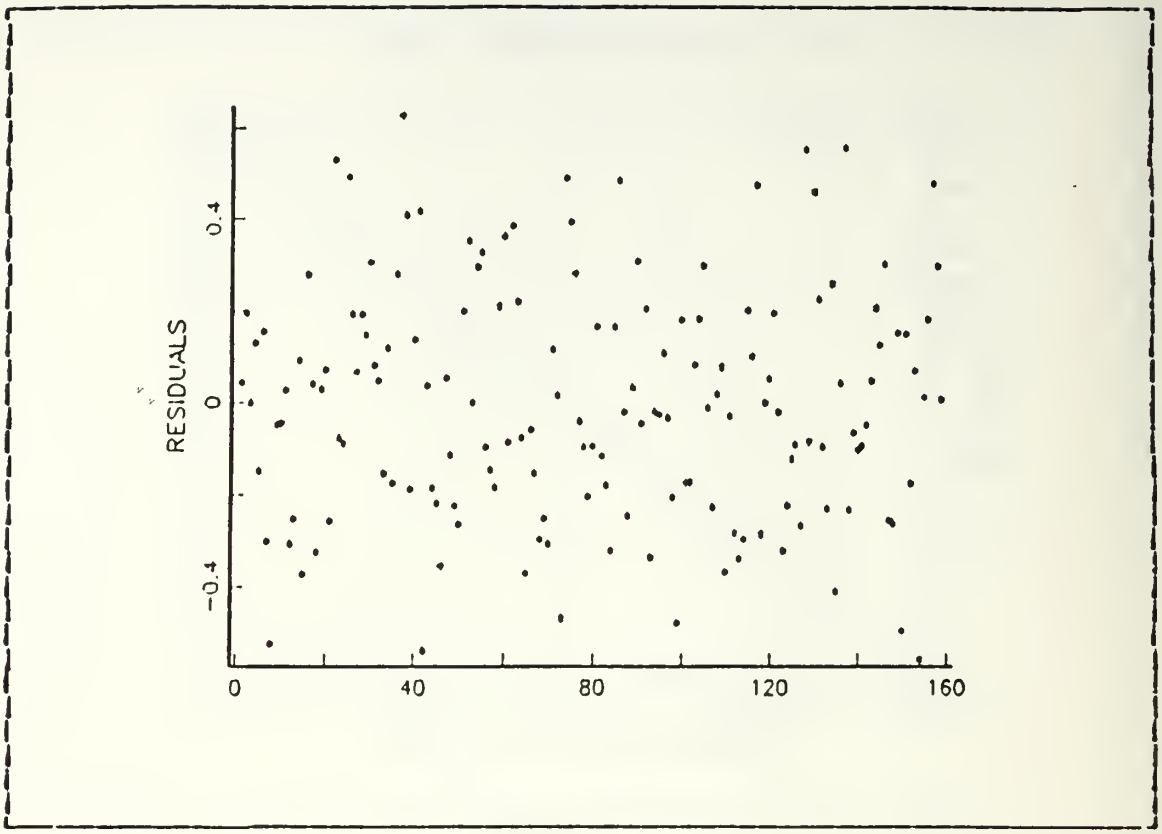


Figure 5.3 Scatter Plot of Residuals :Study Model.

coefficient (r) was calculated for the entire data matrix. Table XI is the results of these calculations. Several of the variables were looked at as both main effects (qualitative) and, after a transformation of the data, as cofactors (quantitative). In these cases of correlation between two scales of the same variable, a high r will be calculated. In all other possible correlations, the r value is low enough to be able to assume independence between the variables of the study.

The serial autocorrelation statistic was used to verify that the error terms were independent. This statistic is provided by the output menu of the "ANOVA" program. For the error terms to be considered independent, the serial

TABLE XI

CORRELATION BETWEEN THE STUDY VARIABLES

Column/Row	Title
1	APC1
2	APC2
3	APC3
4	4th Qtr Qpr
5	6th Qtr Qpr
6	8th Qtr Qpr
7	8th Qtr Total Qpr
8	College Degree
9	Designator
10	Time Since College
11	Refresher (Yes: or no)
12	College Rating (Gourman scale)
13	Year Graduated NPS

1	.46	.02	-.38	-.36	-.36	-.39	.10	-.08	.19	-.16	.21	-.11
	1	.25	-.24	-.18	-.18	-.22	-.09	-.11	.16	-.17	.16	.19
		1	-.15	-.14	-.15	-.16	.07	.06	.02	-.18	-.21	.23
			1	.91	.91	.96	-.14	.21	.12	.17	.06	.13
				1	.97	.95	-.11	.19	.11	.20	.08	.18
					1	.98	-.11	.23	.11	.21	.09	.16
						1	-.12	.23	.11	.18	.09	.16
							1	-.11	-.10	.03	.00	.03
								1	.27	.03	.00	-.06
									1	-.23	.10	.20
										1	.00	-.03
											1	-.02
												1

autocorrelation statistic should be equal to zero [Ref. 7: page 450]. For the model of choice, this statistic was equal to .06 and hence the error terms are considered to be independent.

A total of forty different models were analyzed by the "ANOVA" package. The four covariance models of highest interest will be discussed individually. While these four models use the fourth quarter qpr as the dependent variable, each of the other three qpr's were analyzed as the dependent variable also. The results of those analyses were not significantly different from the 4th quarter models.

E. THE TWO COFACTOR AND SIX MAIN EFFECTS MODEL WITH INTERACTIONS

This model used time since college and college rating as cofactors and the three academic profile codes, college degree, refresher (yes or no) and year graduated from NPS as main effects. The model included the interactions between APC1 and APC2, APC1 and college degree, and college degree and refresher (yes or no). Table XII is the ANOVA table from the "ANOVA" program.

The coefficient of multiple determination (R^2) of .532 is the highest of any of the models analyzed in the study. Thus this model is able to explain 53% of the variability in fourth quarter OA grades by Navy students. The model is relatively significant (.006) but only the one variable, time since college, is individually significant above the .05 level (.029). None of the interactions show any significance. The covariance model is shown in Figure 5.4 .

Table XIII is a listing of the beta coefficients provided as an output from the "ANOVA" program. It is interesting to note that the coefficient for time since college is positive.

TABLE XII

ANOVA TABLE

R-SQUARE = .53 SERIAL AUTOCORRELATION = -.019

SOURCE OF VARIATION	DF	SS	MS	F	SIG
TOTAL	158	17.3	.109		
ERROR	96	8.1	.08		
MODEL	62	9.2	.15	1.75	.006
X1 TIME SINCE COLLEGE	1	.41	.41	4.88	.029
X2 COLLEGE RATING	1	.11	.11	1.30	.257
FACTOR 1 APC1	4	.29	.07	.86	.492
FACTOR 2 APC2	3	.08	.03	.31	.818
FACTOR 3 APC3	5	.34	.07	.82	.539
FACTOR 4 COL. DEGREE	6	.83	.14	1.63	.147
FACTOR 5 REFRESHER	1	.07	.07	.83	.366
FACTOR 6 YR GRAD NPS	11	.83	.08	.89	.549
INTERACTION 1 X 2	9	.86	.10	1.14	.345
INTERACTION 1 X 4	16	1.28	.08	.95	.516
INTERACTION 4 X 5	5	.38	.08	.90	.485

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 X_{i7} + \beta_8 X_{i1} X_{i2} + \beta_9 X_{i1} X_{i4} + \beta_{10} X_{i4} X_{i5} + e_i \qquad i = 1, \ldots, 159$$

Figure 5.4 Two Cofactor and Six M/E Model with Interactions.

F. THE TWO COFACTOR : SIX MAIN EFFECTS MODEL WITHOUT INTERACTIONS

This model is the same as the previous section's model, however, the insignificant interactions were not included. Table XIV is the ANOVA table from the "ANOVA" program.

The coefficient of multiple determination (R^2) has decreased to .373 but the significance of the model has improved a bit to .0004. Now both time since college

TABLE XIII

BETA COEFFICIENTS

TERM	BETA COEFFICIENTS	
COVARIABLES		
X(1):	.025	Time Since College
X(2):	.073	College Rating
CONSTANT:	3.642	
MAIN EFFECTS		
FACTOR (1):	APC1	APC Code
LEVEL(1):	.203	APC0
LEVEL(2):	-.068	APC1
LEVEL(3):	-.134	APC2
LEVEL(4):	-.142	APC3
LEVEL(5):	.141	APC4
FACTOR (2):	APC2	
LEVEL(1):	.038	APC0
LEVEL(2):	.054	APC1
LEVEL(3):	-.046	APC2
LEVEL(4):	-.046	APC3
FACTOR (3):	APC3	
LEVEL(1):	.019	APC0
LEVEL(2):	-.010	APC1
LEVEL(3):	-.060	APC2
LEVEL(4):	.045	APC3
LEVEL(5):	-.078	APC4
LEVEL(6):	.084	APC5
FACTOR (4):	COLLEGE DEGREE	
LEVEL(1):	.509	Business
LEVEL(2):	-.029	Engineering
LEVEL(3):	.259	Humanities
LEVEL(4):	-.017	Math
LEVEL(5):	-.295	Social Science
LEVEL(6):	-.340	Naval Science
LEVEL(7):	.087	Operations Analysis
FACTOR (5):	REFRESHER	
LEVEL(1):	-.116	Refresher Yes
LEVEL(2):	.116	Refresher No
FACTOR (6):	YEAR GRADUATED NPS	
LEVEL(1):	-.133	1974
LEVEL(2):	-.115	1975
LEVEL(3):	-.056	1976
LEVEL(4):	.186	1977
LEVEL(5):	.284	1978
LEVEL(6):	-.088	1979
LEVEL(7):	.032	1980
LEVEL(8):	-.109	1981
LEVEL(9):	.064	1982
LEVEL(10):	-.068	1983
LEVEL(11):	-.042	1984
INTERACTIONS	APC1 X APC2 INTERACTIONS	
NUMBER (1):		
LEVEL(1):	-.089	1 X 1
LEVEL(2):	.213	1 X 2
LEVEL(3):	.032	1 X 3
LEVEL(4):	.447	2 X 1
LEVEL(5):	-.275	2 X 2
LEVEL(6):	.125	2 X 3
LEVEL(7):	-.073	3 X 1
LEVEL(8):	-.341	3 X 2
LEVEL(9):	.248	4 X 1

TABLE XIII

BETA COEFFICIENTS (cont'd.)

NUMBER (2):		
LEVEL(1):	-1.332	1 X 1
LEVEL(2):	-.660	1 X 2
LEVEL(3):	-.688	1 X 3
LEVEL(4):	-.043	1 X 4
LEVEL(5):	.472	1 X 5
LEVEL(6):	-.114	1 X 6
LEVEL(7):	.013	2 X 1
LEVEL(8):	.377	2 X 3
LEVEL(9):	.422	2 X 4
LEVEL(10):	.067	2 X 5
LEVEL(11):	-.155	3 X 2
LEVEL(12):	-.085	3 X 3
LEVEL(13):	.156	3 X 6
LEVEL(14):	.113	4 X 1
LEVEL(15):	.311	4 X 4
LEVEL(16):	.340	4 X 5
NUMBER (3):	4 X 5 INTERACTION	
LEVEL(1):	.192	1 X 1
LEVEL(2):	.134	2 X 1
LEVEL(3):	-.591	3 X 1
LEVEL(4):	.046	4 X 1
LEVEL(5):	.025	5 X 1

(significance of .03) and APC1 (significance of .005) are seen to be very significant factors. This version of the covariance model is simple with fewer terms and is shown in Figure 5.5 .

Table XV is a listing of the beta coefficients provided as an output from the "ANOVA" program. The levels of the APC1 variable are seen to contribute positively at the first two levels and negatively at the lower three levels as one would logically expect. The APC2 variable also "behaves" in a similar fashion from level one through level four.

TABLE XIV

ANOVA TABLE

R-SQUARE = .37 SERIAL AUTOCORRELATION = .017

SOURCE OF VARIATION	DF	SS	MS	F	SIG
TOTAL	158	17.3	.109		
ERROR	126	10.9	.09		
MODEL	32	6.4	.20	2.34	.0004
X1 TIME SINCE COLLEGE	1	.41	.41	4.79	.030
X2 COLLEGE RATING	1	.12	.12	1.43	.234
FACTOR 1 APC1	4	1.33	.33	3.86	.005
FACTOR 2 APC2	3	.22	.07	.84	.475
FACTOR 3 APC3	5	.35	.07	.81	.547
FACTOR 4 COL. DEGREE	6	.92	.15	1.79	.106
FACTOR 5 REFRESHER	1	.00	.00	.01	.974
FACTOR 6 YR GRAD NPS	11	.59	.53	.62	.801

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 X_{i7} + e_i \qquad i = 1, \ldots, 159$$

Figure 5.5 Two C/F and Six M/E Model without Interactions.

G. THE FOUR COFACTOR AND THREE MAIN EFFECTS MODEL WITH INTERACTIONS

The next model uses the variables time since college, college rating, year graduated from NPS and length of refresher as cofactors. It includes APC1, college degree and designator as main effects. The model also evaluates the interaction between APC1 and college degree. This covariance model has a coefficient of multiple determination

TABLE XV

BETA COEFFICIENTS

TERM	BETA COEFFICIENTS	
COVARIABLES		
X(1):	.026	Time Since College
X(2):	.064	College Rating
CONSTANT:	3.371	
MAIN EFFECTS		
FACTOR (1):	APC1	APC Code
LEVEL(1):	.352	APC0
LEVEL(2):	.149	APC1
LEVEL(3):	-.007	APC2
LEVEL(4):	-.070	APC3
LEVEL(5):	-.424	APC4
FACTOR (2):	APC2	
LEVEL(1):	.055	APC0
LEVEL(2):	.054	APC1
LEVEL(3):	-.032	APC2
LEVEL(4):	-.077	APC3
FACTOR (3):	APC3	
LEVEL(1):	.066	APC0
LEVEL(2):	.026	APC1
LEVEL(3):	-.072	APC2
LEVEL(4):	.007	APC3
LEVEL(5):	-.095	APC4
LEVEL(6):	.068	APC5
FACTOR (4):	COLLEGE DEGREE	
LEVEL(1):	.148	Business
LEVEL(2):	.079	Engineering
LEVEL(3):	-.166	Humanities
LEVEL(4):	.022	Math
LEVEL(5):	-.099	Social Science
LEVEL(6):	-.128	Naval Science
LEVEL(7):	.144	Operations Analysis
FACTOR (5):	REFRESHER YES OR NO	
LEVEL(1):	-.001	Refresher Yes
LEVEL(2):	.001	Refresher No
FACTOR (6):	YEAR GRADUATED NPS	
LEVEL(1):	-.075	1974
LEVEL(2):	-.151	1975
LEVEL(3):	.074	1976
LEVEL(4):	.105	1977
LEVEL(5):	-.048	1978
LEVEL(6):	.015	1979
LEVEL(7):	.134	1980
LEVEL(8):	-.040	1981
LEVEL(9):	.006	1982
LEVEL(10):	-.055	1983
LEVEL(11):	.011	1984
LEVEL(12):	.024	1985

of .466 while the significance of the model is .000026. The significant variables were time since college (.026), APC1 (.008), college degree (.027) and designator (.004). Table XVI is the ANOVA table from the "ANOVA" program.

TABLE XVI

ANOVA TABLE

R-SQUARE = .47 SERIAL AUTOCORRELATION = -.004

SOURCE OF VARIATION	DF	SS	MS	F	SIG
TOTAL	158	17.3	.109		
ERROR	119	9.3	.08		
MODEL	39	8.1	.21	2.66	.00003
X1 TIME SINCE COLLEGE	1	.39	.39	5.07	.026
X2 COLLEGE RATING	1	.15	.15	1.90	.171
X3 YR GRAD NPS	1	.03	.03	.37	.545
X4 LENGTH OF REFRESHER	1	.07	.07	.87	.355
FACTOR 1 APC1	4	1.13	.28	3.65	.008
FACTOR 2 COLLEGE DEGREE	6	1.16	.19	2.48	.027
FACTOR 3 DESIGNATOR	8	1.88	.23	3.02	.004
INTERACTION 1 X 2	17	1.01	.06	.77	.730

Once again the interaction term does not appear to be significant. The particular covariance model is shown in Figure 5.6 .

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 X_{i7} + \beta_8 X_{i8} + \beta_9 X_{i1} X_{i2} + e_i \qquad i = 1, \ldots, 159$$

Figure 5.6 4 Cofactor and 3 M/E Model with Interactions.

Table XVII is a listing of the beta coefficients from the "ANOVA" program. It can be seen that the variable length of refresher contributes negatively to the overall performance average. The APC1 variable performs logically in decreasing order from the 0 code to the lower APC1 code of 4.

TABLE XVII

BETA COEFFICIENTS

TERM	BETA COEFFICIENTS	
COVARIABLES		
X(1):	.022	Time Since College
X(2):	.076	College Rating
X(3):	.005	Year Graduated NPS
X(4):	-.035	Length of Refresher
CONSTANT:	3.231	
MAIN EFFECTS		
FACTOR (1):	APC1	APC Code
LEVEL(1):	.798	APC0
LEVEL(2):	.262	APC1
LEVEL(3):	.024	APC2
LEVEL(4):	-.063	APC3
LEVEL(5):	-1.021	APC4
FACTOR (2):	COLLEGE DEGREE	
LEVEL(1):	.376	Business
LEVEL(2):	.138	Engineering
LEVEL(3):	-.194	Humanities
LEVEL(4):	.016	Math
LEVEL(5):	-.246	Social Science
LEVEL(6):	-.251	Naval Science
LEVEL(7):	.161	Operations Analysis
FACTOR (3):	DESIGNATOR	
LEVEL(1):	-.177	1100
LEVEL(2):	-.041	1110
LEVEL(3):	.217	1120
LEVEL(4):	.117	1310
LEVEL(5):	.117	1320
LEVEL(6):	.082	1400
LEVEL(7):	.056	1610
LEVEL(8):	.183	3100
LEVEL(9):	-.554	1130
INTERACTIONS	APC1 X APC2 INTERACTION	
NUMBER (1):		
LEVEL(1):	-.926	1 X 1
LEVEL(2):	-.422	1 X 2
LEVEL(3):	-.385	1 X 3
LEVEL(4):	.076	1 X 4
LEVEL(5):	-.437	1 X 5
LEVEL(6):	-.148	1 X 6
LEVEL(7):	.014	2 X 1
LEVEL(8):	2.146	2 X 3
LEVEL(9):	.300	2 X 4
LEVEL(10):	-.152	2 X 5
LEVEL(11):	-.350	3 X 1
LEVEL(12):	-.030	3 X 2
LEVEL(13):	.020	3 X 3
LEVEL(14):	.122	3 X 6
LEVEL(15):	.148	4 X 1
LEVEL(16):	.310	4 X 4
LEVEL(17):	.334	4 X 5

H. STUDY MODEL :THREE MAIN EFFECTS :FOUR COFACTORS :NO INTERACTIONS

The interaction between the variables APC1 and college degree was removed and the resulting model is the one

selected as the study model. Once again the four cofactors are time since college, college rating, year graduated from NPS and length of refresher. The main effects are the first academic profile code (APC1), college degree and designator. The model is seen in Figure 5.7 .

$$Y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 X_{i7} + e_i \qquad i = 1, \ldots, 159$$

Figure 5.7 4 Cofactor and 3 M/E Model without Interactions.

Table XVIII is the ANOVA table from the "ANOVA" program. The coefficient of multiple determination is .408 and the model has an extremely high significance of .00000007. This model shows the significance of time since college (.015), APC1 (.00002), college degree (.032) and designator (.004) to all be important factors in explaining the variability in fourth quarter gpr's of students in the OA curriculum.

Table XIX is a listing of the beta coefficients from the "ANOVA" program. The cofactors time since college, college rating and year graduated from NPS have a positive contribution to the fourth quarter gpr while length of refresher contributes negatively. APC1 behaves in a very logical fashion. The better one's college performance reflects a more positive contribution to the dependent variable (fourth quarter gpr). This same variable contributes in a negative manner as the college gpr decreases to the lower two levels. The college majors of business, engineering, math and operations analysis all have a positive beta coefficient while the social science, humanities and naval science majors have

TABLE XVIII

ANOVA TABLE

R-SQUARE = .41 SERIAL AUTOCORRELATION = .057

SOURCE OF VARIATION	DF	SS	MS	F	SIG
TOTAL	158	17.3	.110		
ERROR	136	10.3	.08		
MODEL	22	7.1	.32	4.25	.00000007
X1 TIME SINCE COLLEGE	1	.46	.46	6.13	.015
X2 COLLEGE RATING	1	.20	.20	2.71	.102
X3 YR GRAD NPS	1	.02	.02	.30	.583
X4 LENGTH OF REFRESHER	1	.08	.08	1.09	.298
FACTOR 1 APC1	4	2.24	.56	7.43	.000
FACTOR 2 COLLEGE DEGREE	6	1.08	.18	2.39	.031
FACTOR 3 DESIGNATOR	8	1.79	.22	2.96	.004

negative coefficients. In this model, all designators except for 1100,1110 and 1130 have a positive beta coefficient. Although this model did not have the highest coefficient of multiple determination, it is a straightforward, significant model.

TABLE XIX

BETA COEFFICIENTS

TERM	BETA COEFFICIENTS	
COVARIABLES		
X(1):	.023	Time since college
X(2):	.083	College Rating
X(3):	.004	Year Graduated NPS
X(4):	-.037	Length of Refresher
CONSTANT:	3.265	
MAIN EFFECTS		
FACTOR (1):	APC1	
LEVEL(1):	.351	APC0
LEVEL(2):	.195	APC1
LEVEL(3):	.001	APC2
LEVEL(4):	-.114	APC3
LEVEL(5):	-.433	APC4
FACTOR (2):	COLLEGE DEGREE	
LEVEL(1):	.061	Business
LEVEL(2):	.138	Engineering
LEVEL(3):	-.175	Humanities
LEVEL(4):	.033	Math
LEVEL(5):	-.097	Social Science
LEVEL(6):	-.101	Naval Science
LEVEL(7):	.141	Operations Analysis
FACTOR (3):	DESIGNATOR	
LEVEL(1):	-.091	1100
LEVEL(2):	-.045	1110
LEVEL(3):	.218	1120
LEVEL(4):	.100	1310
LEVEL(5):	.117	1320
LEVEL(6):	.072	1400
LEVEL(7):	.030	1610
LEVEL(8):	.148	3100
LEVEL(9):	-.549	1130

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The study shows some interesting insights into evaluating future performance in regards to the Operations Analysis curriculum. It would initially seem quite logical to assume that the longer an individual has been out of college the harder it would be for him or her to return and succeed in the academic environment. However, this does not appear to be the case as reflected by this study. In searching for an explanation, motivation could play a major role. Those students who start a curriculum middle to late in their military service, have most likely decided to make the service a career. They are likely to realize how important successful completion of their chosen subspecialty is to their remaining time in the service and are consequently willing and ready to make whatever effort is required to accomplish that goal. More correctly, they are out to do the best they can possibly do while earning their degree. This grouping would also imply that they are most probably of an age to have their families and a maturity to be able to concentrate their efforts toward a long term goal.

In almost every model tested, the variable for college academic performance (APC1) was seen to be a significant factor. Surprisingly, the math (APC2) and technical code (APC3) did not prove to be very meaningful in the manner of explaining the variability of student performance. Given a choice it appears to be more logical to select a student based on his performance in his chosen field rather than to strictly choose based on his undergraduate degree.

The negative contribution of length of refresher probably means those individuals who need it most are in fact getting the extra quarter or two. This is possibly confounded by the ability to get an extra quarter or two "after the fact", in that, early poor performance can "flag" a student and draw attention to him. With liasion between the curricular officer and the student's detailor, an additional quarter or two can get added to his tour at NPS.

With the possible exception of business majors, there are nc surprises in the college degree variable. Those students with college majors of math, engineering, operations analysis and business in fact nave performed as an average better than the humanities and social science majors.

The designator variable was in fact significant to the model and showed the designators 1100, 1110 and 1130 to have a negative contribution toward fourth quarter academic performance.

The study population covered only those students who successfully completed the OA curriculum. Of course one would want to infer that the insights gained from the study group would apply to the target group of future OA students. This can not be done in the strict predictive sense but the study can suggest that any selection of future OA students be influenced by these results.

The model preferred by the author is discussed in section H of Chapter V. This model has an R^2 value of .41 while another model investigated (section E of Chapter V) attains an R^2 of .53. The model of section H has a much higher level of significance and is a simpler less complex model.

B. RECOMMENDATIONS

A very interesting study to complement this one would be to investigate those Navy students who started but did not complete the OA curriculum during the last ten years. The study group would not be very large but it could possibly provide additional insight into the problem.

Recent interest has been generated to have all NPS students take the Graduate Record Examination (GRE). Currently, this predictor is available for very few individuals in this study. Exactly when the test will be taken is still to be determined but a study combining academic profile codes and the GRE could prove to be much more successful in developing a predictive model. In this regard, the recommendation that the APC's and GRE scores be maintained by NPS as a permanent part of the student's transcript is a necessity for future studies of this type.

Another study of interest would be to determine the validity and usefulness of the newly established Technical Transition Program. This new program will require a few years before the data can be collected studied but adequate records must be maintained in order to evaluate it in the future.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

APC	Academic Profile Code
APC1	Academic Profile Code 1st Digit
APC2	Academic Profile Code 2nd Digit
APC3	Academic Profile Code 3rd Digit
ARE	Academic Record Evaluation
GRE	Graduate Record Examination
NMPC	Naval Military Personnel Command
NPS	Naval Postgraduate School
OA	Operations Analysis
QPR	Quality Point Rating
r	Pearson's Product Moment Correlation Coefficient
R^2	Coefficient of Multiple Determination
TTP	Technical Transition Program

ACADEMIC RECORD EVALUATION

NPS 5040/2 (12-81)

Year Group _____

SSN 1-8	NAME 11-18

COLLEGE (Undergraduate/Graduate)	DEGREE	MAJOR	DATE

SOURCE CODE 17	EPC 18	TOTAL QPR 20-22	FINAL YEAR QPR 24-26	CLASS STANDING 28-34

ACADEMIC PROFILE CODE			GRE SCORES			GMAT SCORES			
QPR	MATH	TECH	V	Q	DATE	T	V	Q	DATE
36	38	40	42-44	46-48	50-61	53-56	57-58	60-61	63-64

ABSTRACT FROM TRANSCRIPT

SUBJECT AREA	NUMBER OF GRADES IN EACH SUBJECT AREA					
	A	B	C	D	F	W
MATH – PRE-CALCULUS	66	67	68	69	70	71
CALCULUS	73	74	75	76	77	78
CARD NO. 2 POST CALCULUS	17	18	19	20	21	22
COMPUTERS, NUMERICAL ANALYSIS	24	25	26	27	28	29
STATISTICS	31	32	33	34	35	36
PHYSICS – LOWER DIVISION	38	39	40	41	42	43
UPPER DIVISION	46	46	47	48	49	50
CHEMISTRY	52	53	54	55	56	57
OTHER PHYSICAL SCIENCE*	59	60	61	62	63	64
AERONAUTICAL/MECHANICAL ENGINEERING	66	67	68	69	70	71
ELECTRICAL ENGINEERING	73	74	75	76	77	78
CARD NO. 3 OTHER ENGINEERING	17	18	19	20	21	22
ACCOUNTING	24	25	26	27	28	29
ECONOMICS	31	32	33	34	35	36
BUSINESS ADMIN/MANAGEMENT	38	39	40	41	42	43
HISTORY	46	46	47	48	49	50
GOVERNMENT/INTERNATIONAL RELATIONS	52	53	54	55	56	57
	59	60	61	62	63	64
	66	67	68	69	70	71

*Meteorology, Oceanography, Geology

APPENDIX C
THE STUDY DATA

Column	
1	Index
2	APC1
3	APC2
4	APC3
5	4th QTR QPR
6	6th QTR QRAD QPR
7	8th QTR Total GRAD QPR
8	8th QTR Total QPR
9	College Rating -- Main Effect
10	College Degree 3 = Business 6 = Engineering 7 = Humanities 8 = Math 9 = Social Science 10 = Naval Science 11 = OA
11	Designator 1 = 110X 2 = 111X 3 = 112X 4 = 131X 5 = 132X 6 = 140X 7 = 161X 8 = 310X 9 = 113X
12	Time since college (in months)
13	Refresher (1 = yes, 2 = no)
14	College Rating (cofactor)
15	Year graduated from NPS
16	A selection value
17	Length of Refresher (in quarters)
18	Time since college (main effect)

1	2	2	2	3.07	3.15	3.25	3.20	5	10	1	62	1	4.36	74	1	.5	3
2	1	0	2	3.43	3.21	3.25	3.40	5	10	2	55	1	4.36	74	1	1	2
3	2	0	2	3.29	3.22	3.26	3.33	4	8	6	61	1	3.96	74	1	.5	3
4	2	0	2	3.43	3.24	3.32	3.45	5	8	4	63	1	4.36	74	1	2	3
5	2	2	3	3.11	3.03	3.06	3.03	5	10	8	57	1	4.36	74	1	.5	2
6	4	2	4	3.11	3.08	3.26	3.24	6	6	5	39	1	4.56	74	1	2	2
7	2	0	1	3.04	3.17	3.22	3.15	6	6	2	52	2	4.70	74	1	0	2
8	3	2	3	2.63	2.83	3.08	2.98	5	10	8	63	1	4.36	74	1	.5	3
9	3	2	3	2.85	3.19	3.30	3.22	5	10	2	57	1	4.36	75	1	2	2
10	2	0	3	3.17	3.08	3.13	3.22	6	8	2	58	1	4.69	75	1	1	2
11	2	2	3	3.16	3.21	3.35	3.29	2	9	5	63	2	2.76	75	1	0	3
12	3	2	4	2.99	3.18	3.27	3.16	5	10	8	135	1	4.36	75	1	.5	6
13	2	1	2	3.07	3.08	3.17	3.16	3	3	3	50	1	3.12	75	1	2	2
14	2	1	3	3.09	3.03	3.13	3.18	5	9	2	60	1	4.06	75	1	2	2
15	2	3	4	2.97	3.06	3.13	3.07	5	3	4	75	1	4.21	75	1	2	3
16	1	0	3	3.89	3.83	3.78	3.80	5	8	8	58	2	4.36	75	1	0	2
17	2	0	3	3.31	3.36	3.39	3.37	3	3	4	87	1	3.03	75	1	2	4
18	2	1	2	3.02	3.00	3.16	3.20	5	6	2	75	1	4.4	75	1	.5	3
19	2	2	2	3.35	3.28	3.28	3.35	5	8	4	58	1	4.01	75	1	.5	2
20	1	0	3	3.32	3.33	3.50	3.48	3	8	2	46	1	3.49	75	1	2	2
21	4	2	3	3.02	3.04	3.08	3.06	6	6	4	165	1	4.91	76	1	.5	6
22	4	1	0	3.50	3.41	3.40	3.40	5	11	4	58	1	4.36	76	1	2	2
23	1	0	0	3.59	3.47	3.44	3.53	4	6	4	82	1	3.96	76	1	.5	3
24	3	2	3	3.08	3.28	3.36	3.36	5	10	4	81	2	4.36	76	1	0	3
25	2	2	2	3.76	3.76	3.77	3.77	5	11	2	34	1	4.36	76	1	.5	1
26	2	2	3	3.49	3.49	3.55	3.57	5	11	2	39	2	4.36	76	1	0	2
27	2	0	1	3.58	3.67	3.64	3.62	5	6	5	74	2	4.21	76	1	0	3
28	2	2	3	3.61	3.08	3.41	3.43	6	3	4	57	2	4.54	77	1	0	2
29	2	2	3	3.45	3.42	3.51	3.52	5	9	4	87	2	4.36	77	1	0	4
30	2	2	1	3.79	3.72	3.74	3.79	5	6	5	51	2	4.36	77	1	0	2
31	2	2	3	3.34	3.20	3.07	3.21	5	3	2	58	2	4.36	77	1	0	2
32	1	1	1	3.67	3.52	3.60	3.63	5	8	5	75	2	4.36	77	1	0	3
33	3	2	1	3.21	3.05	3.25	3.17	6	6	4	47	2	4.57	77	1	0	2

34	3	3	2	3.22	3.14	3.27	3.31	5	10	4	82	1	4.36	77	1	2	3
35	0	3	5	3.43	3.40	3.41	3.41	3	3	4	23	2	3.29	78	1	0	1
36	2	1	2	3.60	3.63	3.66	3.64	5	8	2	111	1	4.36	78	1	.5	5
37	3	3	4	3.97	3.98	3.98	3.99	6	3	4	85	1	4.69	79	1	1	4
38	2	3	4	3.91	3.85	3.93	3.89	4	8	3	75	2	3.94	79	1	0	3
39	2	2	1	2.93	3.21	3.32	3.19	3	8	2	46	2	3.15	79	1	0	2
40	3	2	4	3.45	3.41	3.48	3.41	5	11	4	63	1	4.36	79	1	2	3
41	2	1	2	3.66	3.71	3.69	3.68	5	10	2	129	2	4.36	79	1	0	5
42	2	2	3	2.94	3.24	3.27	3.23	5	6	5	52	2	4.17	79	1	0	2
43	2	2	3	3.53	3.49	3.53	3.56	5	11	4	58	2	4.36	79	1	0	2
44	3	2	1	3.32	3.34	3.40	3.40	5	6	4	123	2	4.4	79	1	0	5
45	3	2	3	3.03	3.21	3.33	3.21	5	9	4	123	1	4.36	79	1	.5	5
46	3	3	4	2.78	2.95	3.04	3.01	5	11	2	46	1	4.36	79	1	2	2
47	2	3	4	3.37	3.39	3.37	3.36	5	8	4	70	1	4.12	79	1	2	3
48	3	2	3	3.37	3.23	3.31	3.36	6	8	8	144	1	4.54	79	1	.5	6
49	2	2	3	3.36	3.57	3.60	3.48	5	8	3	99	2	4.36	79	1	0	4
50	2	2	3	3.30	3.49	3.53	3.48	5	11	5	87	2	4.36	79	1	0	4
51	2	3	3	3.58	3.68	3.71	3.65	6	6	2	97	1	4.73	80	1	2	4
52	3	2	3	3.69	3.58	3.56	3.57	5	8	4	109	1	4.36	80	1	1	5
53	0	1	2	3.85	3.83	3.85	3.84	5	11	5	51	2	4.36	80	1	0	2
54	3	2	3	3.73	3.63	3.68	3.71	6	8	8	108	2	4.54	80	1	0	4
55	2	2	1	3.64	3.74	3.77	3.73	5	10	4	87	2	4.36	80	1	0	4
56	1	1	0	3.77	3.80	3.84	3.85	6	6	8	111	2	4.69	80	1	0	5
57	2	1	3	3.12	3.31	3.30	3.19	6	8	2	59	2	4.59	80	1	0	2
58	2	2	3	3.42	3.44	3.57	3.52	5	6	8	88	2	4.39	80	1	0	4
59	1	0	4	3.76	3.77	3.77	3.77	2	8	8	83	2	2.77	80	1	0	3
60	1	2	5	3.73	3.82	3.83	3.81	3	9	8	59	1	3.10	81	1	1	2
61	3	2	2	3.14	3.14	3.32	3.25	5	11	2	51	2	4.36	81	1	0	2
62	2	1	1	3.84	3.82	3.85	3.86	6	9	8	111	2	4.83	81	1	0	5
63	3	3	4	3.48	3.59	3.57	3.51	3	3	4	124	1	3.11	81	1	2	5
64	2	2	3	3.15	3.39	3.40	3.27	5	8	2	46	2	4.36	81	1	0	2
65	2	0	4	3.13	3.43	3.41	3.30	4	8	8	117	2	3.70	81	1	0	5
66	3	2	3	3.22	3.25	3.36	3.32	5	6	2	87	1	4.4	81	1	.5	4
67	3	1	2	3.10	3.23	3.32	3.23	4	8	7	100	2	3.90	81	1	0	4

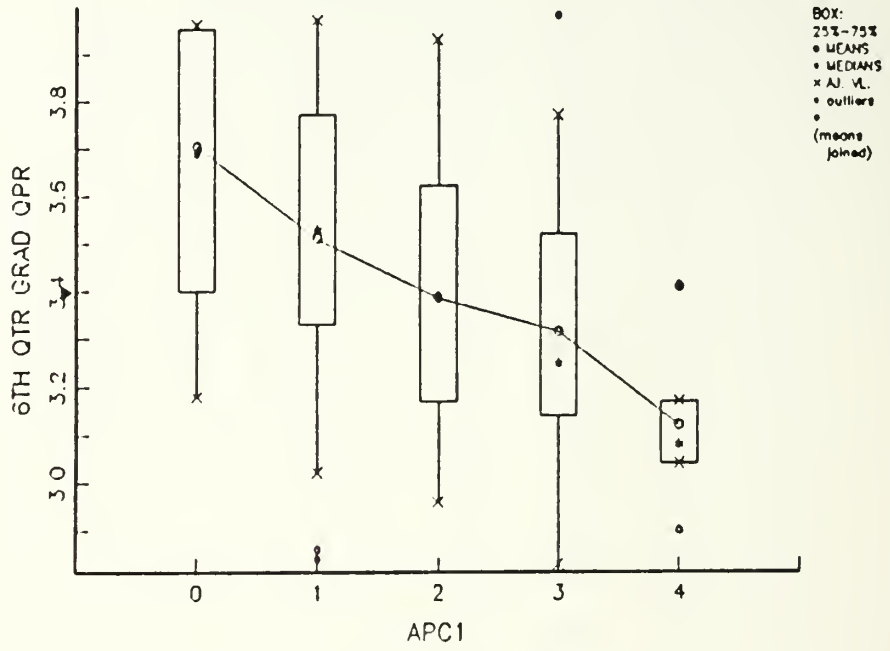
68	3	3	4	3.03	3.11	3.26	3.19	5	11	4	66	1	4.36	81	1	2	3
69	1	2	4	3.46	3.64	3.71	3.62	5	11	5	58	2	4.36	81	1	0	2
70	2	2	4	2.93	3.22	3.25	3.09	5	7	4	94	1	4.36	81	1	.5	4
71	0	0	2	3.97	3.95	3.94	3.94	5	8	3	51	2	4.36	82	1	0	2
72	3	3	5	3.12	3.24	3.24	3.18	4	7	4	147	1	3.52	82	1	2	6
73	4	2	4	2.43	2.90	3.02	2.77	5	11	2	45	2	4.36	82	1	0	2
74	3	3	4	3.76	3.72	3.73	3.75	5	6	2	109	1	4.38	82	1	2	5
75	2	2	3	3.87	3.84	3.83	3.82	6	6	7	63	2	4.76	82	1	0	3
76	2	1	3	3.83	3.88	3.89	3.87	6	8	8	88	2	4.88	82	1	0	4
77	1	0	3	3.36	3.53	3.52	3.44	5	8	2	47	2	4.06	82	1	0	2
78	1	1	1	3.67	3.69	3.75	3.75	6	6	8	69	1	4.57	82	1	.5	3
79	1	1	5	3.59	3.64	3.72	3.71	6	3	8	111	2	4.63	82	1	0	5
80	1	2	2	3.28	3.47	3.49	3.44	4	8	2	47	1	3.95	82	1	.5	2
81	2	0	3	3.56	3.62	3.64	3.63	5	8	5	64	1	4.17	82	1	.5	3
82	2	3	4	3.40	3.42	3.42	3.38	6	3	5	123	1	4.6	82	1	2	5
83	1	0	2	3.27	3.33	3.37	3.36	2	8	5	70	1	2.37	82	1	.5	3
84	2	1	3	2.90	3.06	3.15	3.06	4	8	2	71	1	3.90	82	1	.5	3
85	2	2	5	3.64	3.61	3.60	3.61	6	8	5	88	1	4.59	82	1	.5	4
86	2	2	3	3.65	3.58	3.60	3.66	4	8	1	71	1	3.72	83	1	.5	3
87	3	2	3	3.25	3.40	3.43	3.40	5	8	4	58	1	4.36	83	1	.5	2
88	1	0	4	3.39	3.33	3.38	3.42	4	11	7	75	2	3.97	83	1	0	3
89	3	3	1	3.39	3.52	3.52	3.48	6	6	4	70	1	4.54	83	1	2	3
90	1	1	5	3.83	3.82	3.79	3.81	6	7	5	104	1	4.93	83	1	.5	4
91	2	1	3	3.15	3.05	3.15	3.20	5	8	2	57	1	4.06	83	1	1	2
92	1	1	3	3.43	3.56	3.60	3.56	4	9	2	46	1	3.7	83	1	.5	2
93	2	2	1	2.97	3.09	3.25	3.20	5	6	2	45	2	4.01	83	1	0	2
94	1	0	2	3.75	3.67	3.70	3.73	4	8	5	183	1	3.53	83	1	.5	6
95	0	1	0	3.96	3.96	3.95	3.96	5	6	3	63	2	4.36	83	1	0	3
96	0	0	3	3.99	3.95	3.90	3.90	5	8	3	63	2	4.36	83	1	0	3
97	1	1	5	3.46	3.41	3.40	3.44	3	8	5	76	1	3.35	83	1	2	3
98	2	2	4	2.89	3.00	3.15	3.08	5	9	2	51	1	4.36	83	1	.5	2
99	3	3	4	2.77	2.94	3.07	3.09	4	8	5	86	1	3.93	83	1	2	4
100	0	3	4	3.59	3.67	3.63	3.60	3	9	1	93	1	3.49	83	1	.5	4
101	3	3	3	3.32	3.32	3.31	3.31	5	11	4	118	1	4.36	83	1	.5	5

102	2	2	3	3.30	3.35	3.43	3.43	6	9	4	147	1	4.9	83	1	.5	6
103	3	2	4	3.30	3.10	3.21	3.33	5	11	2	51	1	4.36	83	1	.5	2
104	1	2	3	3.97	3.97	3.96	3.97	6	3	8	106	1	4.85	83	1	.5	4
105	2	1	3	3.70	3.62	3.67	3.72	5	8	2	142	1	4.36	83	1	.5	6
106	2	1	3	3.51	3.46	3.53	3.56	5	11	4	63	2	4.36	83	1	0	3
107	1	3	4	2.62	2.86	3.13	3.09	6	9	9	99	1	4.63	83	1	2	4
108	2	2	1	3.82	3.85	3.86	3.86	6	6	3	135	1	4.9	83	1	.5	6
109	2	3	4	3.19	3.22	3.29	3.31	3	8	2	63	1	3.38	83	1	2	3
110	0	0	2	3.34	3.18	3.33	3.39	4	8	1	171	1	3.93	83	1	1	6
111	3	2	4	3.06	3.22	3.27	3.25	3	9	5	63	2	3.21	83	1	0	3
112	3	3	3	3.07	3.16	3.28	3.23	5	6	2	123	1	4.36	83	1	.5	5
113	2	2	1	3.05	3.27	3.33	3.25	6	8	2	105	2	4.86	83	1	0	4
114	3	2	2	3.08	3.04	3.14	3.19	5	6	2	135	1	4.36	83	1	.5	6
115	2	1	2	3.82	3.77	3.74	3.77	5	11	3	63	1	4.36	83	1	.5	3
116	2	2	4	3.41	3.39	3.45	3.49	5	6	2	45	2	4.03	83	1	0	2
117	3	2	3	3.82	3.77	3.74	3.79	3	8	5	130	2	3.13	84	1	0	5
118	2	2	2	2.95	3.15	3.20	3.13	5	8	2	45	2	4.36	84	1	0	2
119	2	2	3	3.34	3.39	3.46	3.50	5	6	2	45	2	4.36	84	1	0	2
120	2	0	3	3.44	3.45	3.45	3.47	5	8	4	57	1	4.36	84	1	.5	2
121	2	2	4	3.32	3.43	3.47	3.46	6	9	2	45	1	4.81	84	1	.5	2
122	2	3	5	3.11	3.18	3.23	3.20	5	7	4	70	1	4.14	84	1	2	3
123	2	3	2	3.07	3.13	3.15	3.13	6	3	4	59	1	4.69	84	1	2	2
124	3	3	4	2.96	3.02	3.11	3.09	3	8	4	95	1	3.06	84	1	2	4
125	1	2	4	3.47	3.53	3.54	3.54	5	3	4	58	1	4.12	84	1	.5	2
126	2	2	3	3.17	3.25	3.31	3.32	6	8	2	47	2	4.6	84	1	0	2
127	1	2	5	3.35	2.84	2.95	3.10	5	9	3	82	2	4.14	84	1	0	3
128	2	2	3	3.81	3.86	3.87	3.86	6	8	2	47	2	4.55	84	1	0	2
129	2	3	3	3.38	3.54	3.54	3.48	5	8	4	107	1	4.11	84	1	.5	4
130	3	3	3	3.81	3.76	3.54	3.48	5	11	2	118	1	4.36	84	1	.5	5
131	2	2	3	3.14	3.22	3.30	3.27	4	6	9	112	1	3.95	84	1	.5	5
132	3	2	2	3.14	3.04	3.13	3.19	5	6	2	50	2	4.36	84	1	0	2
133	2	3	5	3.00	3.08	3.12	3.12	3	9	5	114	1	3.17	84	1	2	5
134	3	3	3	3.79	3.76	3.79	3.82	5	6	4	164	1	4.4	84	1	2	6
135	1	0	4	3.25	3.02	3.07	3.16	4	8	8	93	1	3.9	84	1	.5	4

136	4	3	4	3.15	3.17	3.22	3.22	5	11	4	111	1	4.36	84	1	2	5
137	3	2	4	3.79	3.62	3.66	3.72	5	6	2	52	2	4.28	84	1	0	2
138	2	2	1	2.98	2.96	2.99	2.99	4	8	2	52	2	3.9	84	1	0	2
139	3	2	3	3.27	3.28	3.35	3.34	5	10	4	159	1	4.36	84	1	.5	6
140	2	1	4	3.42	3.33	3.36	3.39	5	11	5	63	1	4.36	84	1	.5	3
141	2	1	5	3.29	3.23	3.25	3.28	3	8	3	40	2	3.06	84	1	0	2
142	2	2	1	3.38	3.40	3.43	3.40	4	8	4	88	2	3.9	84	1	0	4
143	1	1	3	3.69	3.24	3.67	3.71	3	8	8	100	1	3.5	84	1	.5	4
144	2	3	4	3.84	3.81	3.83	3.82	5	3	8	151	1	4.4	85	1	1	6
145	2	2	3	3.35	3.41	3.46	3.45	5	8	2	46	1	4.36	85	1	.5	2
146	1	0	5	3.82	3.80	3.77	3.78	3	11	2	71	2	3.46	85	1	0	3
147	2	2	4	3.26	3.30	3.36	3.36	5	11	5	58	1	4.36	85	1	.5	2
148	2	2	4	2.83	3.01	3.10	3.05	5	9	2	46	1	4.36	85	1	.5	2
149	0	1	3	3.63	3.69	3.72	3.69	3	8	1	47	2	3.5	85	1	0	2
150	2	3	4	2.83	3.03	3.16	3.13	6	8	1	107	1	4.74	85	1	.5	4
151	2	2	3	3.59	3.63	3.63	3.63	6	8	5	58	1	4.71	85	1	.5	2
152	1	1	2	3.43	3.43	3.48	3.50	5	8	5	58	1	4.36	85	1	.5	2
153	3	2	3	3.30	3.29	3.38	3.39	5	10	2	178	1	4.36	85	1	.5	6
154	2	2	4	2.74	2.99	3.10	3.04	6	8	2	71	1	4.69	85	1	.5	3
155	3	2	4	3.27	3.28	3.33	3.35	5	11	2	58	2	4.36	85	1	0	2
156	2	2	1	3.85	3.82	3.82	3.85	6	8	8	142	2	4.9	85	1	0	6
157	2	2	1	3.98	3.93	3.92	3.93	5	6	5	64	1	4.06	85	1	.5	3
158	1	0	5	3.83	3.77	3.76	3.79	3	8	5	59	1	3.46	85	1	.5	2
159	3	2	1	3.46	3.48	3.55	3.56	5	6	4	94	1	4.36	85	1	.5	4

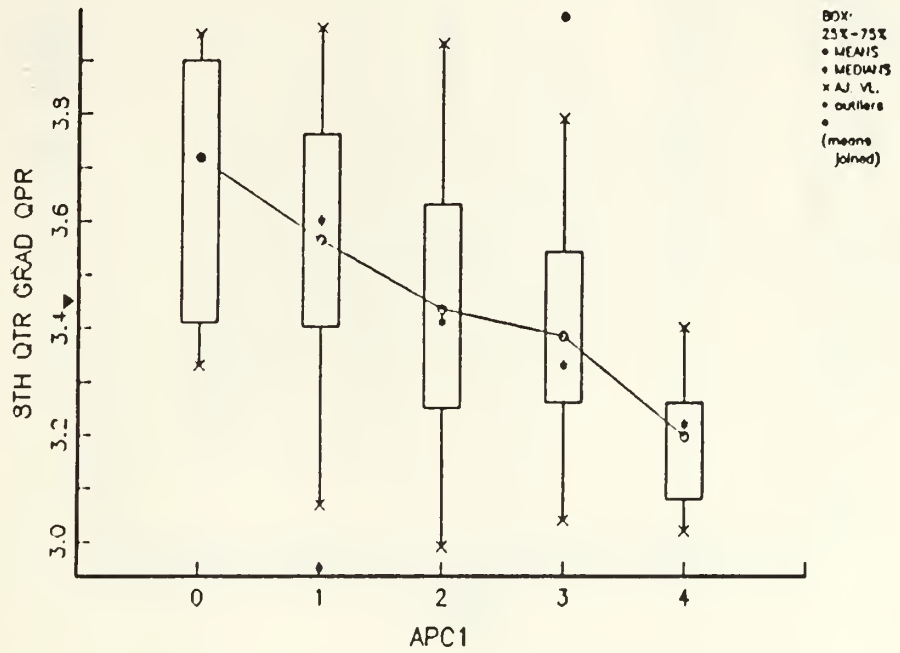
APPENDIX D

ADDITIONAL PRELIMINARY ANALYSIS



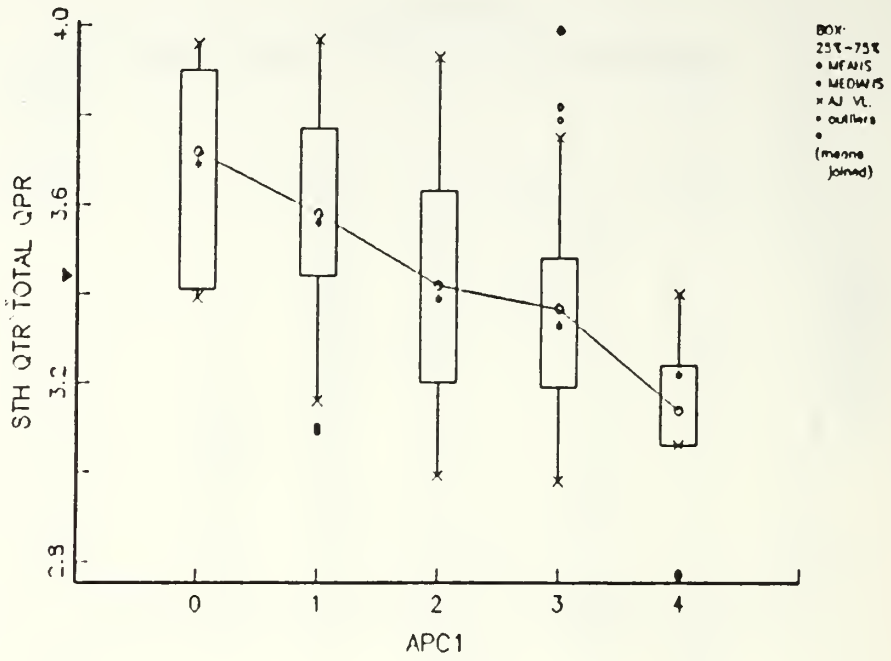
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.398	0.2883	3.18	3.39	3.63
0	8	0.050314	3.7038	0.26711	3.4	3.69	3.95
1	28	0.1761	3.5107	0.28636	3.33	3.53	3.77
2	79	0.49686	3.3857	0.26924	3.17	3.39	3.62
3	39	0.24528	3.3149	0.26347	3.14	3.25	3.52
4	5	0.031447	3.12	0.16912	3.04	3.08	3.17

Figure D.1 6th Qtr Grad QPR vs APC1.



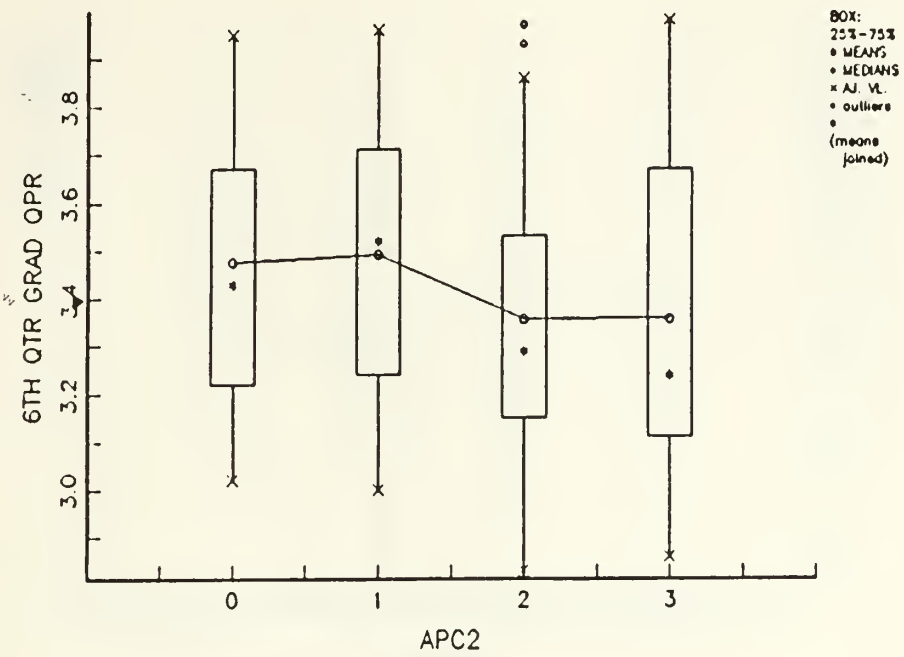
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.4503	0.2524	3.26	3.41	3.66
0	8	0.050314	3.7163	0.2255	3.41	3.72	3.9
1	28	0.1761	3.5632	0.24482	3.4	3.6	3.76
2	79	0.49686	3.4328	0.24519	3.25	3.41	3.63
3	39	0.24528	3.3826	0.21212	3.26	3.33	3.54
4	5	0.031447	3.196	0.1347	3.08	3.22	3.26

Figure D.2 8th Qtr Grad QPR vs APC1.



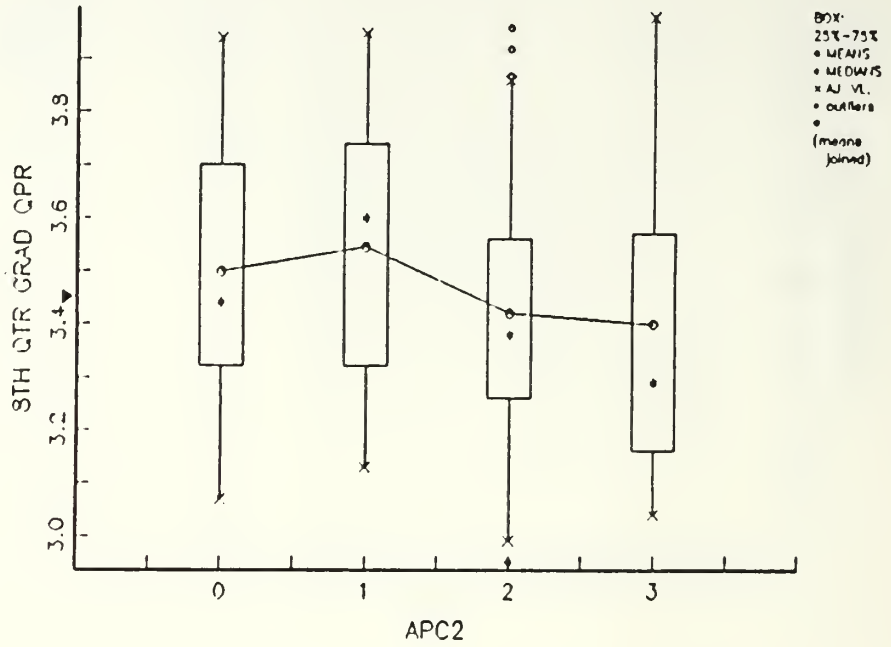
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.4409	0.2634	3.22	3.41	3.65
0	8	0.050314	3.7163	0.21592	3.41	3.69	3.9
1	28	0.1761	3.5782	0.22533	3.44	3.56	3.77
2	79	0.49686	3.4201	0.25442	3.2	3.39	3.63
3	39	0.24528	3.3667	0.22948	3.19	3.33	3.48
4	5	0.031447	3.138	0.2132	3.06	3.22	3.24

Figure D.3 8th Qtr Total QPR vs APC1.



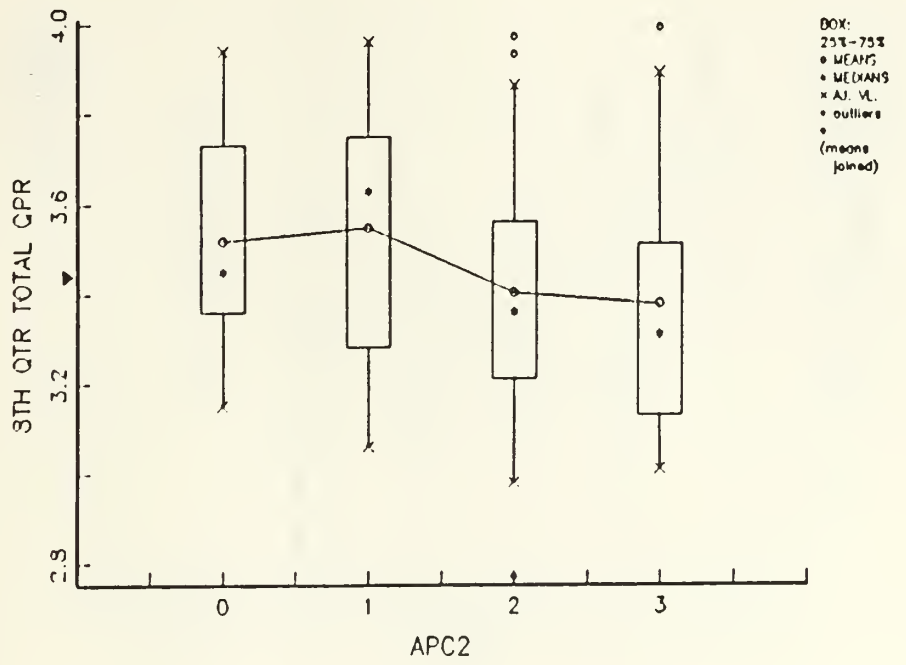
CATEG.	NO. PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.398	0.2883	3.18	3.39	3.63
0	24	0.15094	3.4742	0.27154	3.22	3.43	3.67
1	29	0.18239	3.49	0.28439	3.24	3.52	3.71
2	76	0.47799	3.3551	0.27236	3.15	3.29	3.53
3	30	0.18868	3.3567	0.31022	3.11	3.24	3.67

Figure D.4 6th Qtr Grad QPR vs APC2.



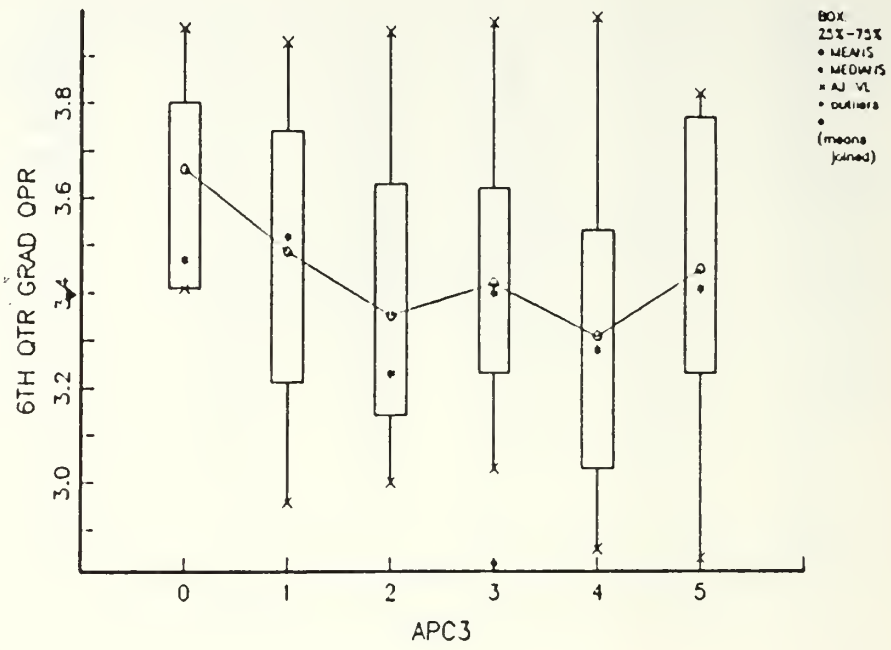
CATEG.	NO. PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.4503	0.2524	3.26	3.41	3.66
0	24	0.15094	3.4975	0.2384	3.32	3.44	3.7
1	29	0.18239	3.5445	0.25465	3.32	3.6	3.74
2	76	0.47799	3.4195	0.23794	3.26	3.38	3.56
3	30	0.18868	3.3993	0.26589	3.16	3.29	3.57

Figure D.5 8th Qtr Grad QPR vs APC2.



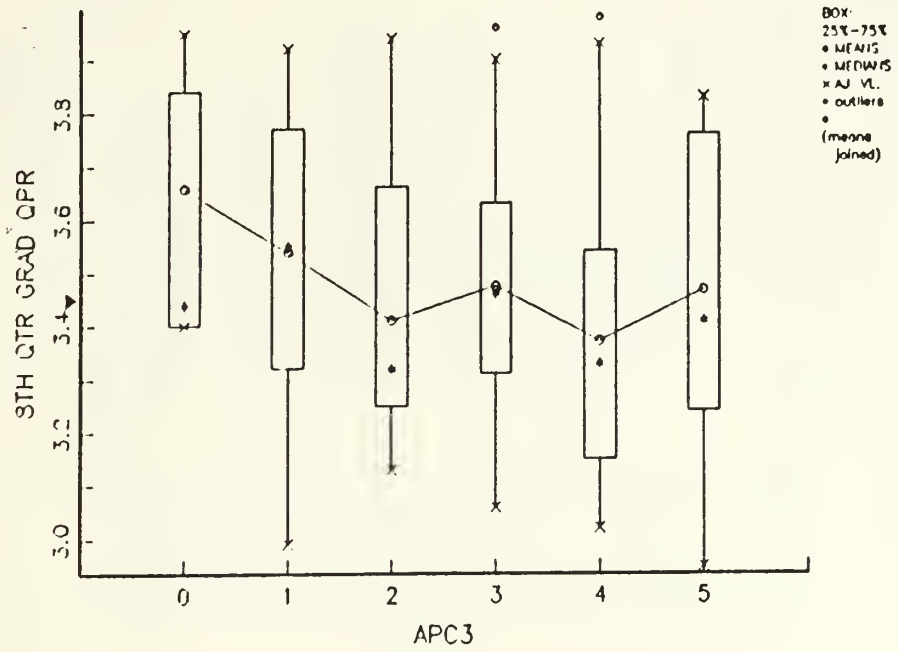
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL CODES	159	1	3.4409	0.2634	3.22	3.41	3.65
0	24	0.15094	3.5179	0.22493	3.36	3.45	3.73
1	29	0.18239	3.5462	0.26059	3.28	3.63	3.75
2	76	0.47799	3.4017	0.2557	3.21	3.36	3.56
3	30	0.18868	3.3767	0.26924	3.13	3.31	3.51

Figure D.6 8th Qtr Total QPR vs APC2.



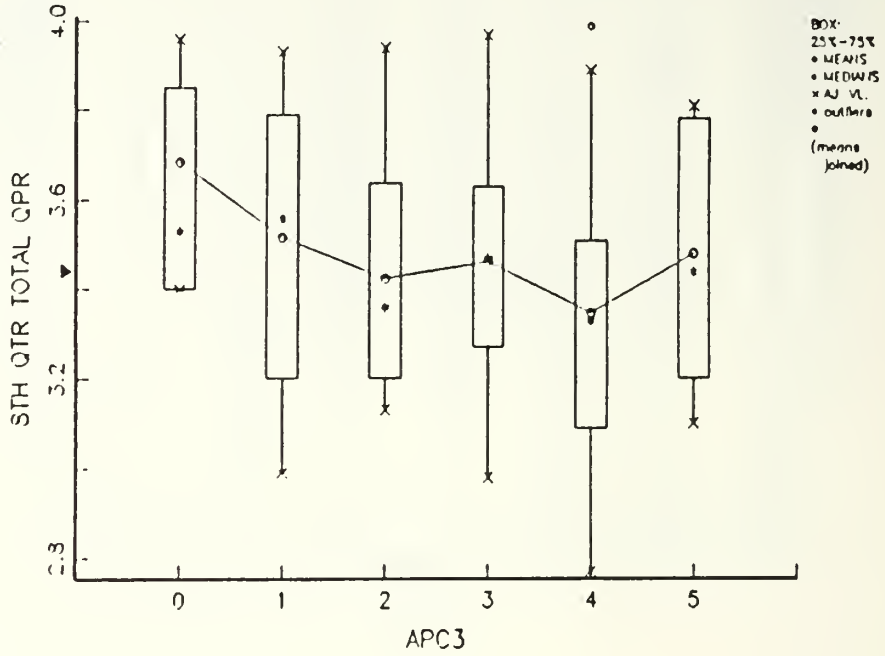
CATEG.	NO.PTS	o/o-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.398	0.2883	3.18	3.39	3.63
0	4	0.025157	3.66	0.22814	3.41	3.47	3.8
1	19	0.1195	3.4868	0.29243	3.21	3.52	3.74
2	25	0.15723	3.3512	0.28053	3.14	3.23	3.63
3	59	0.37107	3.4203	0.25073	3.23	3.4	3.62
4	39	0.24528	3.3069	0.29217	3.03	3.28	3.53
5	13	0.081761	3.4492	0.30871	3.23	3.41	3.77

Figure D.7 6th Qtr Grad QPR vs APC3.



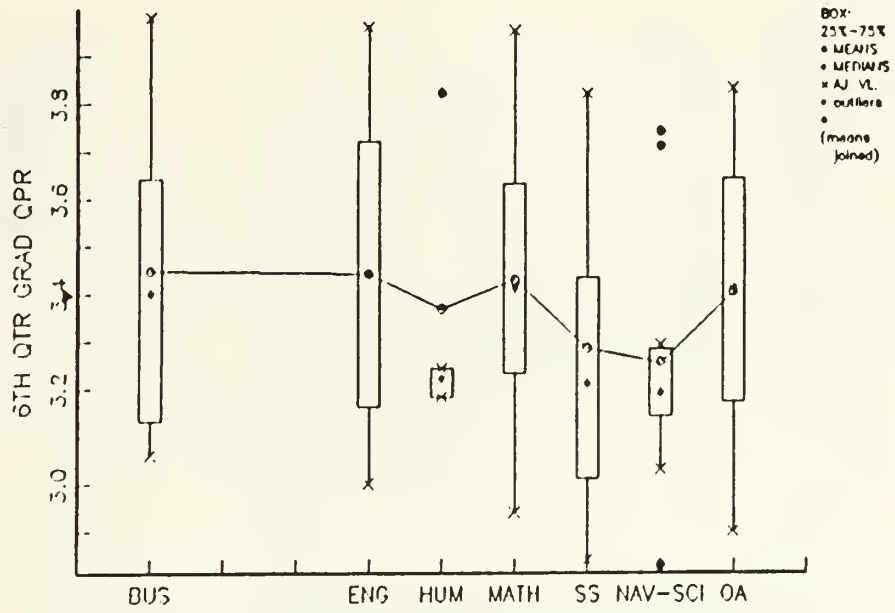
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4503	0.2524	3.26	3.41	3.66
0	4	0.025157	3.6575	0.24108	3.4	3.44	3.84
1	19	0.1195	3.5374	0.25849	3.32	3.55	3.77
2	25	0.15723	3.4096	0.24289	3.25	3.32	3.66
3	59	0.37107	3.4737	0.2243	3.31	3.46	3.63
4	39	0.24528	3.3715	0.25334	3.15	3.33	3.54
5	13	0.081761	3.4669	0.28361	3.24	3.41	3.76

Figure D.8 8th Qtr Grad QPR vs APC3.



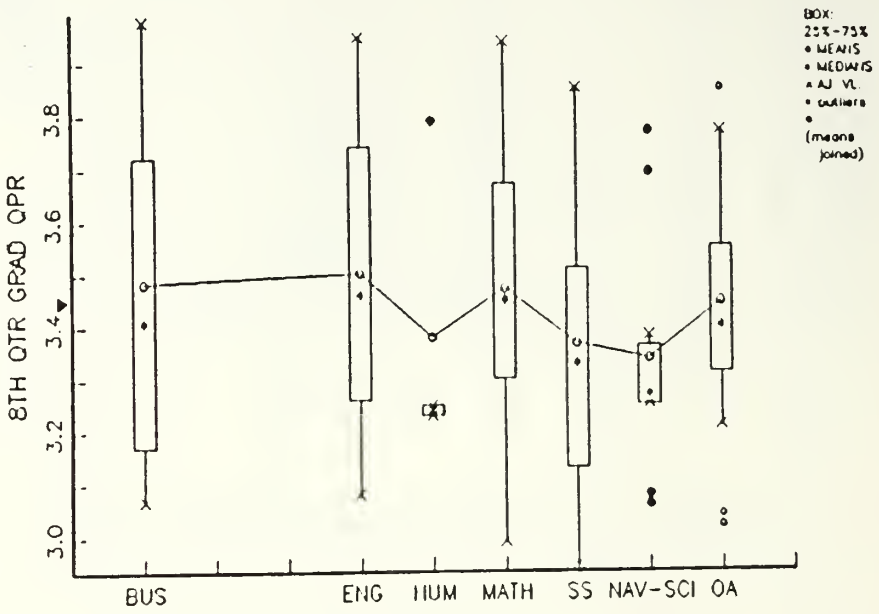
CATEG.	NO.PTS	%/o-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4409	0.2634	3.22	3.41	3.65
0	4	0.025157	3.685	0.22809	3.4	3.53	3.85
1	19	0.1195	3.5163	0.28621	3.2	3.56	3.79
2	25	0.15723	3.4232	0.2404	3.2	3.36	3.64
3	59	0.37107	3.4615	0.23384	3.27	3.47	3.63
4	39	0.24528	3.3462	0.27195	3.09	3.33	3.51
5	13	0.081761	3.48	0.27211	3.2	3.44	3.78

Figure D.9 8th Qtr Total QPR vs APC3.



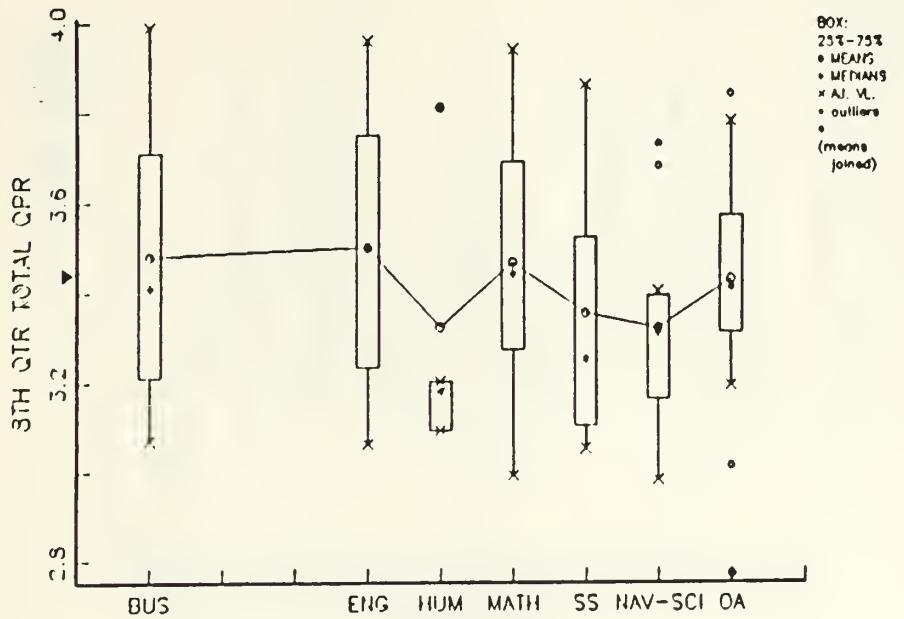
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL MAJORS	159	1	3.398	0.2883	3.18	3.39	3.63
BUSINESS	14	0.08805	3.4464	0.30997	3.13	3.4	3.64
ENGRG	31	0.19497	3.4403	0.30109	3.16	3.44	3.72
HUMANITIES	4	0.025157	3.365	0.26358	3.18	3.22	3.24
MATH	59	0.37107	3.42258	0.27166	3.23	3.41	3.63
SOCIAL SCI	16	0.10063	3.2831	0.30596	3.01	3.21	3.43
NAVAL SCI	12	0.075472	3.2525	0.24359	3.14	3.19	3.28
OA	23	0.14465	3.4017	0.26493	3.17	3.41	3.64

Figure D.10 6th Qtr Grad QPR vs College Degree.



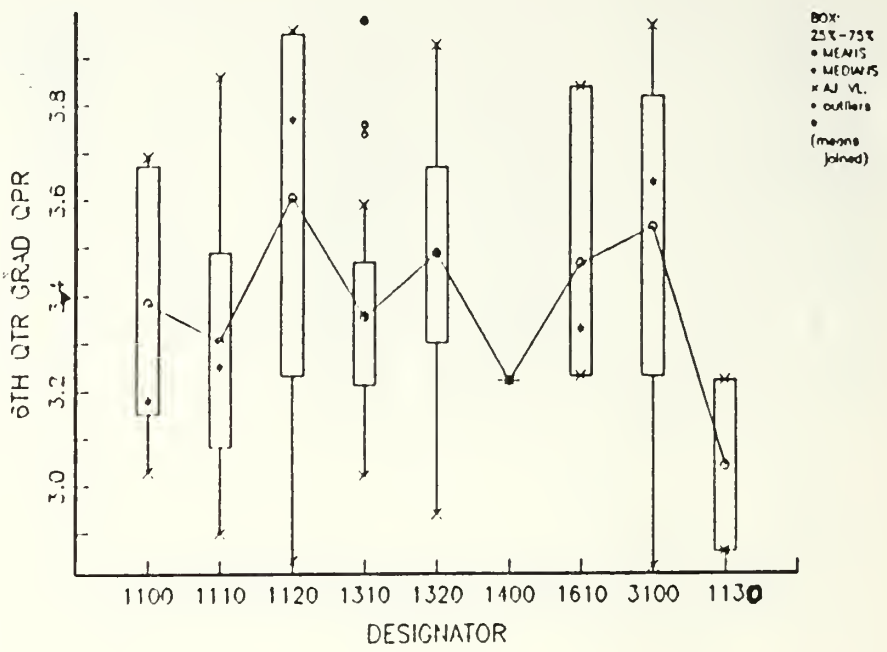
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL MAJORS	159	1	3.4503	0.2524	3.26	3.41	3.66
BUSINESS	14	0.08805	3.4821	0.291145	3.17	3.41	3.72
ENGRG	31	0.19497	3.5003	0.259936	3.26	3.46	3.74
HUMANITIES	4	0.025157	3.3775	0.23826	3.23	3.24	3.25
MATH	59	0.37107	3.47	0.24444	3.3	3.45	3.67
SOCIAL SCI	16	0.10063	3.3656	0.26014	3.13	3.33	3.51
NAVAL SCI	12	0.075472	3.3358	0.2006	3.25	3.27	3.36
OA	23	0.14465	3.4439	0.22145	3.31	3.4	3.55

Figure D.11 8th Qtr Grad QPR vs College Degree.



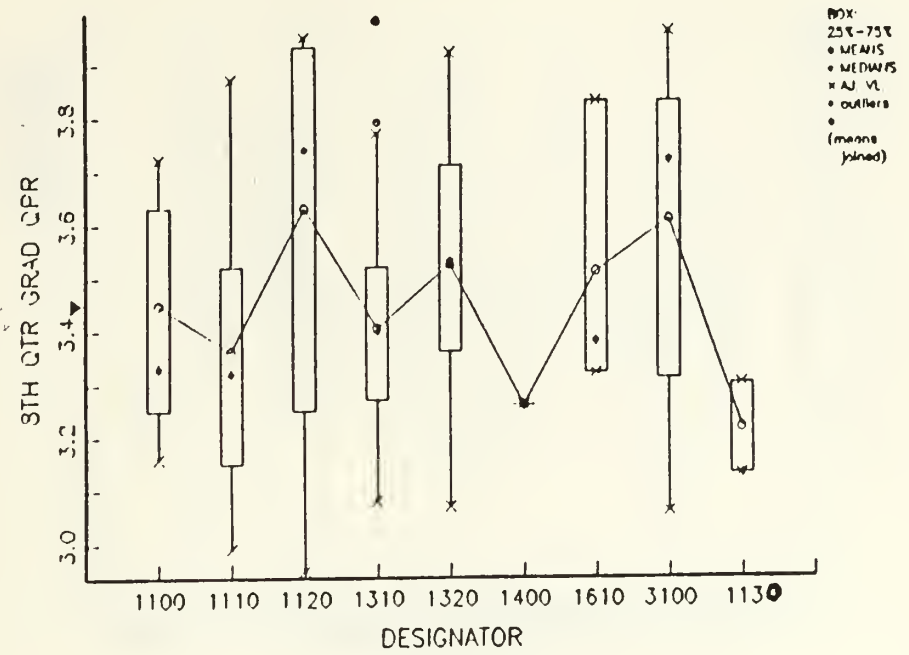
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL MAJORS	159	1	3.4409	0.2634	3.22	3.41	3.65
BUSINESS	14	0.08805	3.4786	0.28891	3.21	3.41	3.71
ENGRG	31	0.19497	3.4984	0.26995	3.23	3.5	3.75
HUMANITIES	4	0.025157	3.32	0.28592	3.09	3.18	3.2
MATH	59	0.37107	3.4647	0.25204	3.27	3.44	3.69
SOCIAL SCI	16	0.10063	3.3506	0.25418	3.1	3.25	3.52
NAVAL SCI	12	0.075472	3.3167	0.21615	3.16	3.31	3.39
OA	23	0.14465	3.4278	0.2468	3.31	3.41	3.57

Figure D.12 8th Qtr Total QPR vs College Degree.



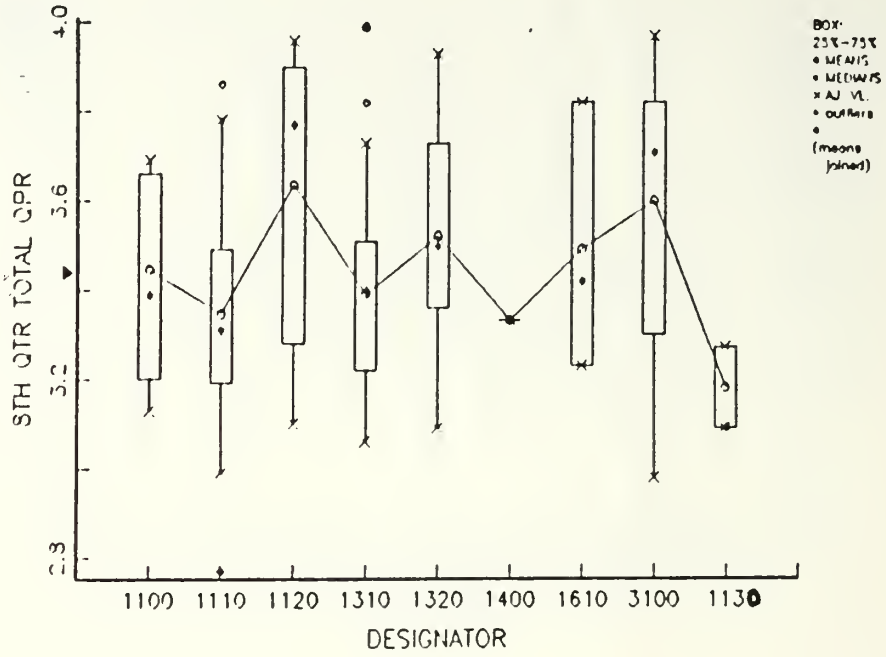
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL DESIGN.	159	1	3.398	0.2883	3.18	3.39	3.63
1100	6	0.037736	3.3833	0.26942	3.15	3.18	3.67
1110	50	0.31447	3.303	0.26013	3.08	3.25	3.49
1120	10	0.062893	3.605	0.38911	3.23	3.77	3.95
1310	41	0.25786	3.3541	0.20709	3.21	3.36	3.47
1320	26	0.16352	3.4877	0.25731	3.3	3.49	3.67
1400	1	0.0062893	3.22	0	3.22	3.22	3.22
1610	3	0.018868	3.4667	0.26712	3.23	3.33	3.84
3100	20	0.12579	3.544	0.33361	3.23	3.64	3.82
1130	2	0.012579	3.04	0.18	2.86	2.86	3.22

Figure D.13 6th Qtr Grad QPR vs Designator.



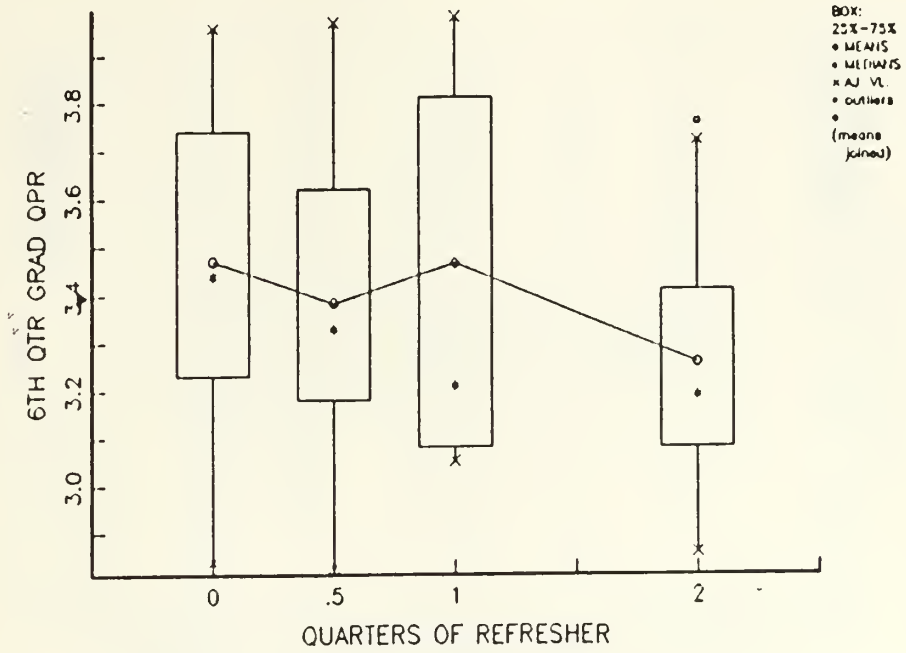
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL DESIGN.	159	1	3.4503	0.2524	3.26	3.41	3.66
1100	6	0.037736	3.4483	0.21067	3.25	3.33	3.63
1110	50	0.31447	3.3616	0.2255	3.15	3.32	3.52
1120	10	0.062893	3.629	0.35294	3.25	3.74	3.93
1310	41	0.25786	3.4041	0.18104	3.27	3.4	3.52
1320	26	0.16352	3.5223	0.22378	3.36	3.53	3.71
1400	1	0.0062893	3.26	0	3.26	3.26	3.26
1610	3	0.018868	3.51	0.2276	3.32	3.38	3.83
3100	20	0.12579	3.608	0.28889	3.31	3.72	3.83
1130	2	0.012579	3.215	0.085	3.13	3.13	3.3

Figure D.14 8th Qtr Grad QPR vs Designator.



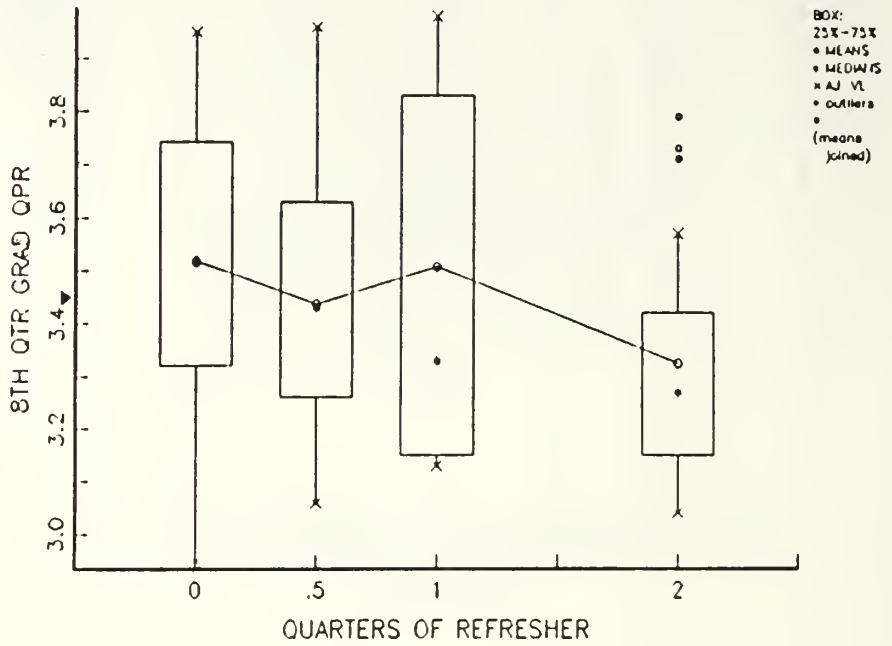
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL DESIGN.	159	1	3.4409	0.2634	3.22	3.41	3.65
1100	6	0.037736	3.445	0.22081	3.2	3.39	3.66
1110	50	0.31447	3.3466	0.2391	3.19	3.31	3.49
1120	10	0.062893	3.634	0.32629	3.28	3.77	3.9
1310	41	0.25786	3.3917	0.19701	3.22	3.4	3.51
1320	26	0.16352	3.5212	0.23296	3.36	3.5	3.73
1400	1	0.0062893	3.33	0	3.33	3.33	3.33
1610	3	0.018868	3.49	0.2459	3.23	3.42	3.82
3100	20	0.125[illegible]79	3.5995	0.30603	3.3	3.71	3.82
1130	2	0.012579	3.18	0.09	3.09	3.09	3.27

Figure D.15 8th Qtr Total QPR vs Designator.



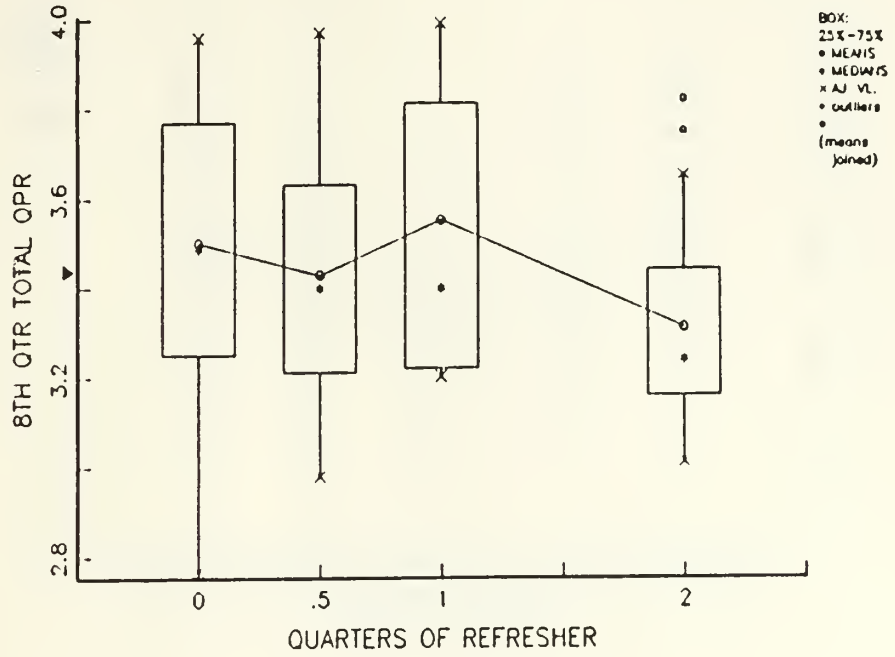
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL QTRS	159	1	3.398	0.2883	3.18	3.39	3.63
0	63	0.39623	3.4702	0.28855	3.23	3.44	3.74
0.5	58	0.36478	3.3833	0.27511	3.18	3.33	3.62
1	8	0.050314	3.4638	0.35181	3.08	3.21	3.81
2	30	0.18868	3.2573	0.23245	3.08	3.19	3.41

Figure D.16 6th Qtr Grad QPR vs Length of Refresher.



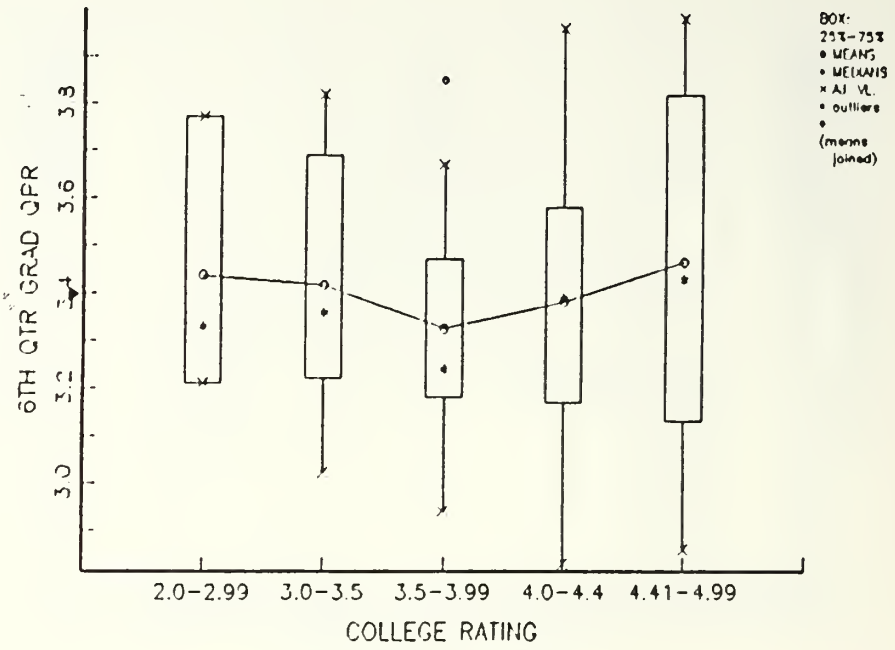
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL QTRS	159	1	3.4503	0.2524	3.26	3.41	3.66
0	63	0.39623	3.5168	0.25817	3.32	3.52	3.74
0.5	58	0.36478	3.4353	0.23415	3.26	3.43	3.63
1	8	0.050314	3.5075	0.31665	3.15	3.33	3.83
2	30	0.18868	3.324	0.19592	3.15	3.27	3.42

Figure D.17 8th Qtr Grad QPR vs Length of Refresher.



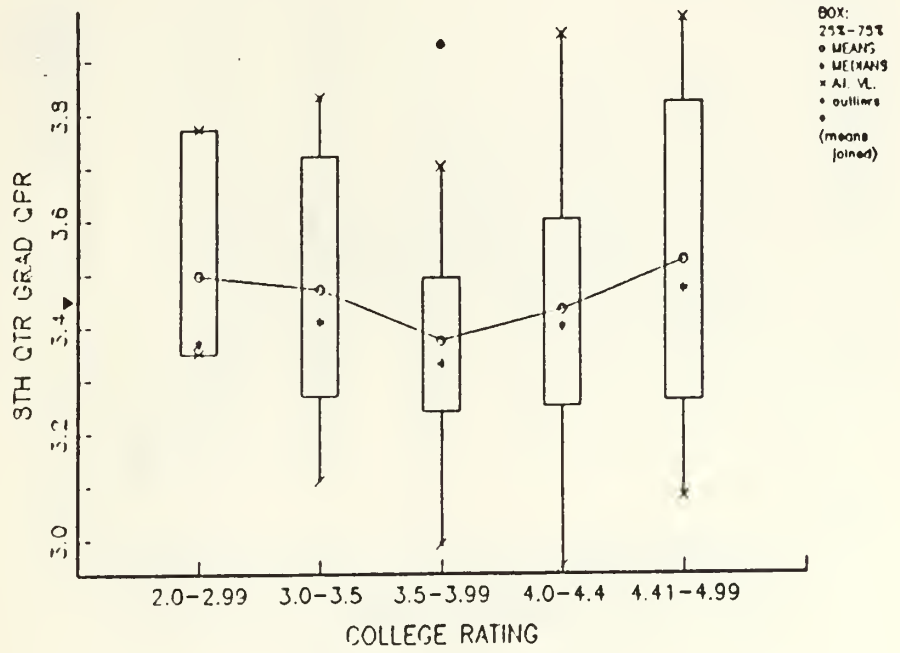
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL QTRS	159	1	3.4409	0.2634	3.22	3.41	3.65
0	63	0.39623	3.5005	0.27381	3.25	3.49	3.77
0.5	58	0.36478	3.4286	0.25112	3.21	3.4	3.63
1	8	0.050314	3.55	0.27704	3.22	3.4	3.81
2	30	0.18868	3.3103	0.19982	3.16	3.24	3.44

Figure D.18 8th Qtr Total QPR vs Length of Refresher.



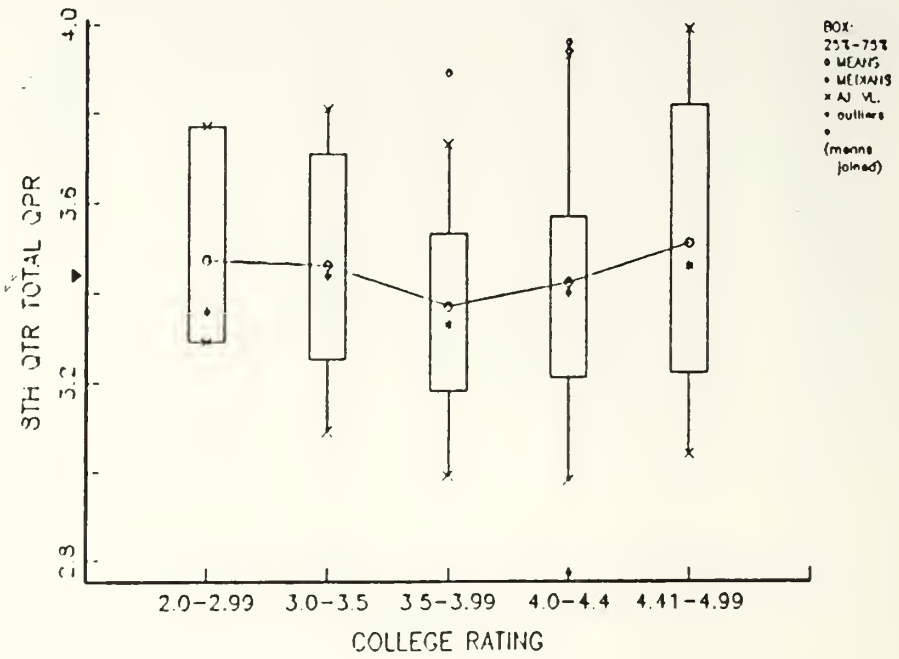
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.398	0.2883	3.18	3.39	3.63
2.0-2.99	3	0.018868	3.4367	0.24074	3.21	3.33	3.77
3.0-3.50	19	0.1195	3.4163	0.26252	3.22	3.36	3.69
3.5-3.99	18	0.11321	3.3239	0.24468	3.18	3.24	3.47
4.0-4.40	85	0.53459	3.3814	0.27817	3.17	3.39	3.58
4.41-4.99	34	0.21384	3.465	0.33393	3.13	3.43	3.82

Figure D.19 . 6th Qtr Grad QPR vs College Rating.



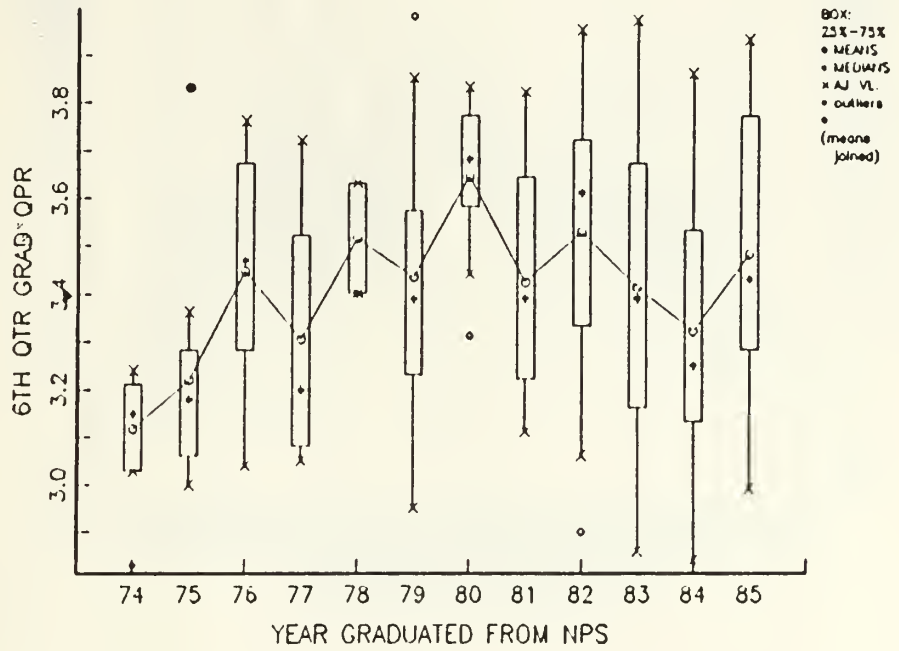
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4503	0.2524	3.26	3.41	3.66
2.0-2.99	3	0.018868	3.4967	0.19345	3.35	3.37	3.77
3.0-3.5	19	0.1195	3.4695	0.23123	3.27	3.41	3.72
3.5-3.99	18	0.11321	3.3728	0.23137	3.24	3.33	3.49
4.0-4.4	85	0.53459	3.4319	0.24036	3.25	3.4	3.6
4.41-4.99	34	0.21384	3.5224	0.28697	3.26	3.47	3.82

Figure D.20 8th Qtr Grad QPR vs College Rating.



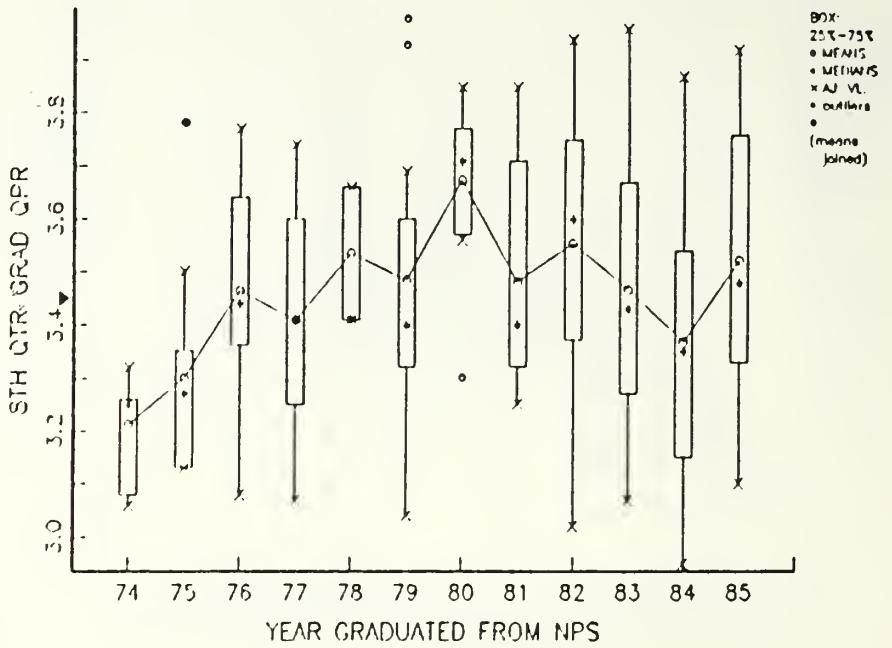
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4409	0.2634	3.22	3.41	3.65
2.0-2.99	3	0.018868	3.4733	0.21171	3.29	3.36	3.77
3.0-3.5	19	0.1195	3.4621	0.24126	3.25	3.44	3.71
3.5-3.99	18	0.11321	3.3683	0.23448	3.18	3.33	3.53
4.0-4.4	85	0.53459	3.4228	0.25242	3.21	3.4	3.57
4.41-4.99	34	0.21384	3.5097	0.30149	3.22	3.46	3.82

Figure D.21 8th Qtr Total QPR vs College Rating.



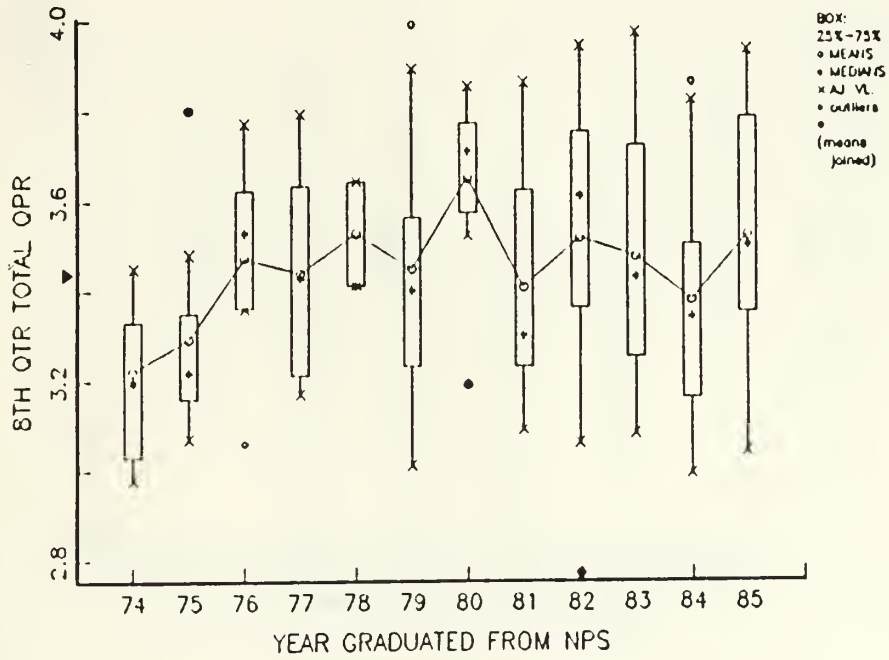
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.398	0.2883	3.18	3.39	3.63
1974	8	0.050314	3.1163	0.12727	3.03	3.15	3.21
1975	12	0.075472	3.2192	0.21589	3.06	3.18	3.28
1976	7	0.044025	3.4457	0.22199	3.28	3.47	3.67
1977	7	0.044025	3.3043	0.23469	3.08	3.2	3.52
1978	2	0.012579	3.515	0.115	3.4	3.4	3.63
1979	14	0.08805	3.4336	0.2669	3.23	3.39	3.57
1980	9	0.056604	3.6422	0.16423	3.58	3.68	3.77
1981	11	0.069182	3.4218	0.24822	3.22	3.39	3.64
1982	15	0.09434	3.5267	0.2876	3.33	3.61	3.72
1983	31	0.19497	3.4106	0.31246	3.16	3.39	3.64
1984	27	0.16981	3.3204	0.26655	3.13	3.25	3.53
1985	16	0.10063	3.4794	0.30202	3.28	3.43	3.77

Figure D.22 6th Qtr Grad QPR vs Year Graduated NPS.



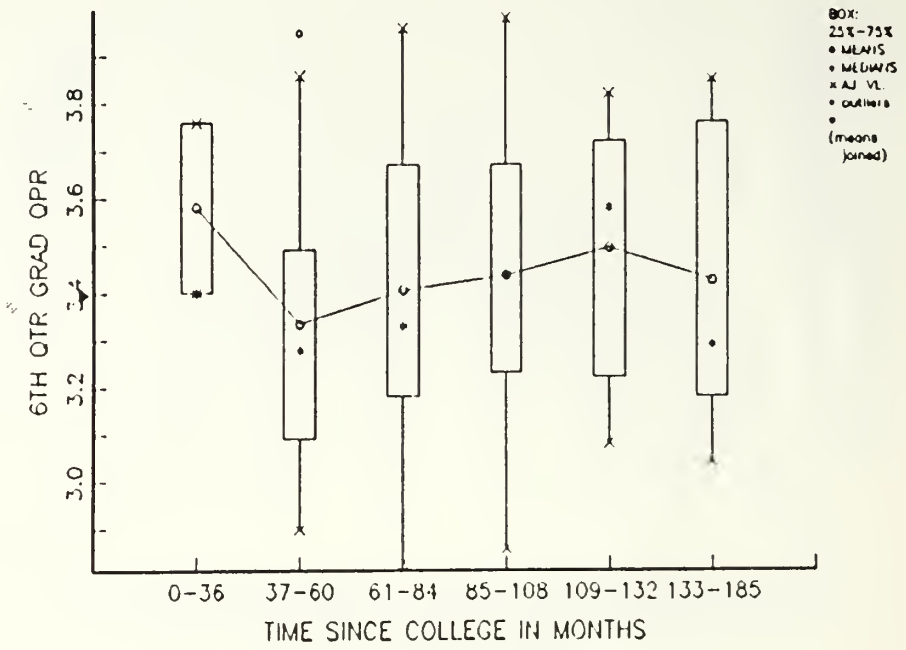
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4503	0.2524	3.26	3.41	3.66
1974	8	0.050314	3.2125	0.086422	3.08	3.25	3.26
1975	12	0.075472	3.2992	0.18382	3.13	3.27	3.35
1976	7	0.044025	3.4629	0.20527	3.36	3.44	3.64
1977	7	0.044025	3.4071	0.21238	3.25	3.41	3.6
1978	2	0.012579	3.535	0.125	3.41	3.41	3.66
1979	14	0.08805	3.4843	0.24625	3.32	3.4	3.6
1980	9	0.056604	3.6722	0.16396	3.57	3.71	3.77
1981	11	0.069182	3.48	0.2129	3.32	3.4	3.71
1982	15	0.09434	3.554	0.26439	3.37	3.6	3.75
1983	31	0.19497	3.4661	0.25627	3.27	3.43	3.67
1984	27	0.16981	3.3667	0.24291	3.15	3.35	3.54
1985	16	0.10063	3.523	0.26076	3.33	3.48	3.76

Figure D.23 8th Qtr Grad QPR vs Year Graduated NPS.



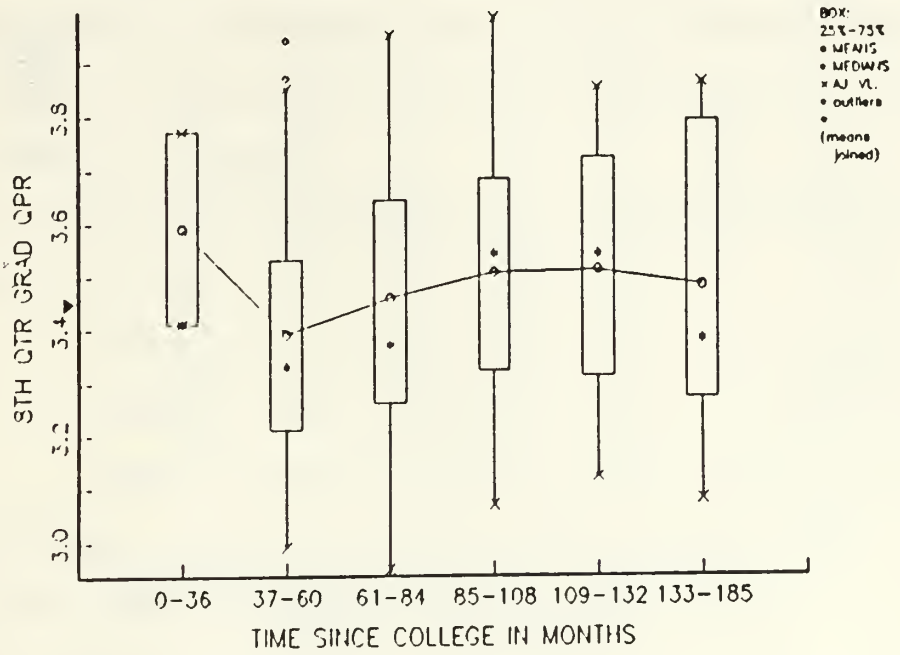
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4409	0.2634	3.22	3.41	3.65
1974	8	0.050314	3.2225	0.15682	3.03	3.2	3.33
1975	12	0.075472	3.2917	0.18672	3.16	3.22	3.35
1976	7	0.044025	3.4729	0.21083	3.36	3.53	3.62
1977	7	0.044025	3.4371	0.20967	3.21	3.43	3.63
1978	2	0.012579	3.525	0.115	3.41	3.41	3.64
1979	14	0.08805	3.4464	0.25903	3.23	3.4	3.56
1980	9	0.0566604	3.6478	0.19303	3.57	3.71	3.77
1981	11	0.0691182	3.4045	0.24585	3.23	3.3	3.62
1982	15	0.09434	3.514	0.31603	3.36	3.61	3.75
1983	31	0.19497	3.4735	0.26266	3.25	3.43	3.72
1984	27	0.16981	3.3763	0.241	3.16	3.34	3.5
1985	16	0.10063	3.52	0.27729	3.35	3.5	3.78

Figure D.24 8th Qtr Total QPR vs Year Graduated NPS.



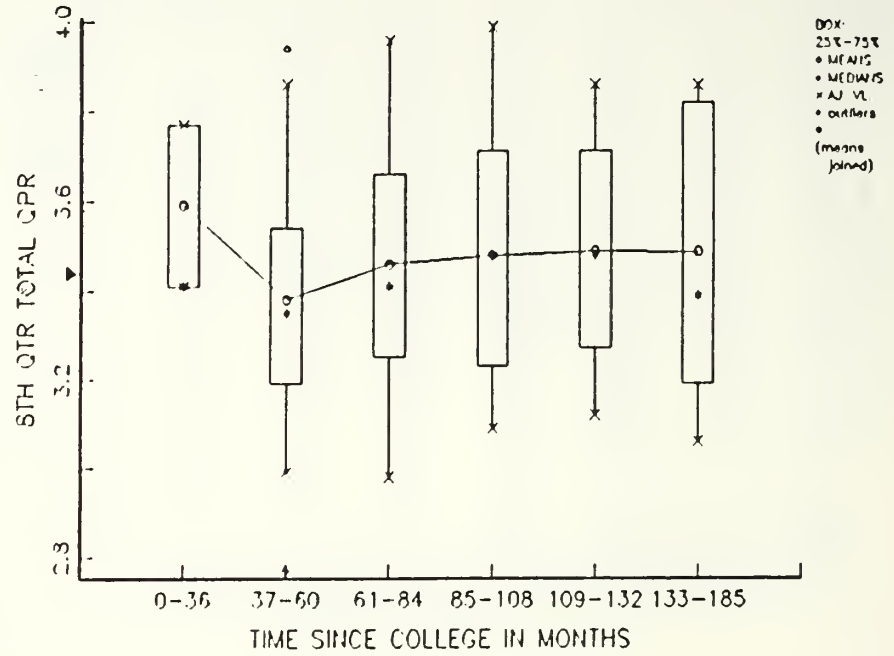
CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4503	0.2524	3.26	3.41	3.66
0-36	2	0.012579	3.59	0.18	3.41	3.41	3.77
37-60	58	0.36478	3.3897	0.23747	3.21	3.33	3.53
61-84	38	0.23899	3.4558	0.26435	3.26	3.37	3.64
85-108	27	0.16981	3.5037	0.2609	3.32	3.54	3.68
109-132	19	0.1195	3.51	0.21369	3.31	3.54	3.72
133-185	15	0.09434	3.48	0.26092	3.27	3.38	3.79

Figure D.25 6th Qtr Grad QPR vs Time Since College.



CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.4409	0.2634	3.22	3.41	3.65
0-36	2	0.012579	3.59	0.18	3.41	3.41	3.77
37-60	58	0.36478	3.3798	0.25011	3.19	3.35	3.54
61-84	38	0.23899	3.4579	0.2712	3.25	3.41	3.66
85-108	27	0.16981	3.4781	0.27162	3.23	3.48	3.71
109-132	19	0.1195	3.4884	0.23293	3.27	3.48	3.71
133-185	15	0.09434	3.4867	0.27538	3.19	3.39	3.82

Figure D.26 8th Qtr Grad QPR vs Time Since College.



CATEG.	NO.PTS	%-PTS	Y-MEAN	Y-DVN	.25	.50	.75
ALL	159	1	3.398	0.2883	3.18	3.39	3.63
0-36	2	0.012579	3.58	0.18	3.4	3.4	3.76
37-60	58	0.36478	3.3324	0.26608	3.09	3.28	3.49
61-84	38	0.23899	3.4039	0.30993	3.18	3.33	3.67
85-108	27	0.16981	3.4356	0.30548	3.23	3.44	3.67
109-132	19	0.1195	3.4932	0.24151	3.22	3.58	3.72
133-185	15	0.09434	3.424	0.28621	3.18	3.29	3.76

Figure D.27 8th Qtr Total QPR vs Time Since College.

APPENDIX E

Welcome to the Anova package.

This package was developed by Prof. Russell Richards at NPS. The latest revision occurred on May 21, 1985. Please provide your comments to Prof. Richards in Root 271.

Type DESCRIBE for basic documentation. Other instructions are obtained by typing:

EXTRACTHOW (explains the use of the function extract)

GLOBAL (lists the global variables in the workspace)

SYNTAX (shows the syntax for use of several functions)

In addition, the function called, AOVUTY, provides a menu of options which should be somewhat self-explanatory.

This package is still under development.

To use the general linear model package for analysis of variance, you must first enter your data in the form required. Your need an N X 1 array, Y, containing the observed values of the dependent variables, an N X NCOV array, COV. containing the values of the NCOV covariables (NCOV may be 0), and an N X NF array, data containing the subscripts of the NF factors to be considered in the analysis. Note: The columns of data contain subscripts which must be integers 1, 2, ..., M where M is the number of levels of a factor. You can execute the function called RECODE to rewrite the values in data so that they satisfy this requirement (simply type RECODE). The function named EXTRACT may be useful for creating these arrays if the data can be extracted from a larger array which contains the necessary data. Type EXTRACTHOW for info on the use of extract. If you want to enter the data at the

terminal, you can use the function called INPUT.

After the necessary data are entered into the workspace, type RUN 0 to begin the analysis (the argument 0 indicates the initial run with the given data; for subsequent runs using the same data, enter RUN 1). For the first run with a given set of data you will be prompted to enter various information needed by the program. This information includes names for the factors, covariables, and for the job. It also asks if you want to transform the data. If so, the original values of the dependent variable are stored in the array OLDY and a new Y array is created.

With the initialization completed, you will be asked to enter the interactions desired to be included in the analysis (if any). You should enter the interactions by typing a vector containing the numbers of the factors which comprise the interactions. For example, if you want to include interactions between factors 1 and 2; factors 1 and 3; and factors 1, 2, and 3 you should enter the vector 12 13 123.

The program then performs the following tasks:

1. A matrix D having N rows and a number of columns which depends the number of levels of each of the NF factors is generated. This is the portion of the design matrix corresponding to the main effects. It contains only the values 0, 2, and -1. The main effects are automatically normalized so that the main effects sum to 0. A bookkeeping array, DF, of size NF X 2 is also generated. The elements of the ith row of BF indicate which cols of D correspond to the ith factor.

2. An array, DD containing N rows is generated. The number of

cols of DD depends on the number of interactions and the number of levels of each interaction. DD is that portion of the overall design matrix which corresponds to the interaction terms. Like D, DD contains only the values 0, 1, and -1. A scalar, NI, indicating the number of interactions is created, and a bookkeeping array, B1 of size NI X 2 is generated. It indicates which cols of DD correspond to which interactions.

3. The overall design matrix X, is generated by catenating COV, D, and DD.

4. The design matrix is checked to see if it is nonsingular. If not nonsingular, the rank is determined and a set of cols that can be eliminated is indicated. If the design matrix can be made nonsingular by elimination of one or more cols from the interaction set, that is done automatically. If not, program execution terminates.

5. The analysis of variance is performed on the model, Y = XBETA. Output consists of the R-squared statistic, the ANOVA table with the covariable effects. The main effects and the interaction effects all indicated. For each effect, the degrees of freedom, the sum of squares, the mean square, and an F ratio are presented. The error and total sums of squares and degrees of freedom are also given. Finally, summary statistics for each of the covariables and for the dependent variable for each level of each of the main effects are provided. This information consists of the observation counts. The mean, the variance, and the standard deviation. The summary statistics are given for the original data, not the transformed data.

6. Available at the conclusion of the run is a GLOBAL vector called

BETA which contains the estimates of the parameters included in the full model.

7. After the analysis of variance is performed, various utility functions can be performed on the output by executing the function, AOVUTY. That function presents a menu of your choices. The function called EXTRACT can be used to create the input arrays required by the ANOVA package. It should be used when you already have an array from which all of the required data can be extracted. The syntax of the function is:

EXTRACT DATA

Where data is a two-dimensional array.

The EXTRACT function will prompt the user for the information it requires. The user must know which columns of data correspond to the data that he wants to extract.

One of the questions asked is the column of the selection variable. It is assumed that the user wants to select only specific rows of data corresponding to values of a selection variable. For example, suppose the third column of data contains 1 or 2 with 1 representing males and 2 females. If the analysis is to be performed on males only we select those observations with a 1 in column 3.

The values of the variables in the columns that are used to refer to factors must be integers 1, 2, 3, ... etc. that will be used by this package as subscripts (factor level indicators).

After using EXTRACT to create the input data arrays, the user can then perform the analysis of variance by typing RUN 0.

The syntax of the major functions in the ANOVA package are:

EXTRACT ARRAY (Extracts the required data from array)

RECODE (Operates on the GLOBAL array data)

INPUT (Creates the arrays needed for run)

RUN K (K is 0, 1, or 2)

AOVUTY GLOBAL (Consists of various useful utility functions)

This provides a description of the GLOBAL variables used by the ANOVA package. The convention used in naming GLOBALvariables is to always use underscored names for GLOBAL variables.

Y - The vector of values of the dependent variable.

N - The number of observations in Y.

NCOV - The number of covariables to be considered.

COV - The array of size N by NCOV containing the values of the NF.

NF - The number of factors to be considered.

DATA - The array of size N by NF containing the subscripts of the NF factors for each of the N observations.

D - The design matrix containing N rows of the values 0, 1, and -1 corresponding to the main effects to be considered in the model. The number of cols of D depends on the number of levels of the NF factors. A factor having K levels will have K-1 cols in D. K-1 dummy variables will be defined with values 0 or 1. The Kth level is defined so that the sum of the effects is zero.

BG - This is an array of size NF by 2 containing bookkeeping info concerning which factors correspond to which columns of D.

DD - This is an array of N rows containing the portion of the overall design matrix corresponding to the interactions to be considered. It consists entirely of the values 0, 1, and -1. The number of cols of DD depends on the factors and interactions considered.

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