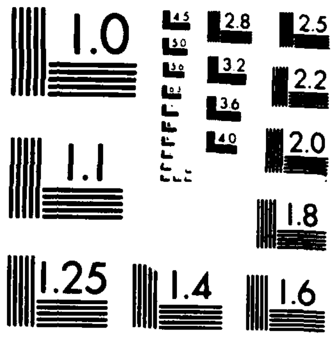
AD-A184 893 ANALYSIS OF INTELLIGENCE AND ACADEMIC SCORES AS A PREDICTOR OF PROMOTION (U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA J B WARNER 06 JUL 87

1/2

UNCLASSIFIED F/G 5/9 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

ANALYSIS OF INTELLIGENCE AND ACADEMIC SCORES AS A PREDICTOR OF PROMOTION RATE FOR U.S. ARMY NONCOMMISSIONED OFFICERS

by

Jerry B. Warner

June 1987

Thesis Advisor: P. A. W. Lewis

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: Unclassified

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution is unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S):

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: Naval Postgraduate School

6b OFFICE SYMBOL (If applicable): 55

7a NAME OF MONITORING ORGANIZATION: Naval Postgraduate School

6c ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5000

7b ADDRESS (City, State, and ZIP Code): Monterey, California 93943-5000

8a NAME OF FUNDING / SPONSORING ORGANIZATION:

8b OFFICE SYMBOL (If applicable):

9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c ADDRESS (City, State, and ZIP Code):

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO

11 TITLE (Include Security Classification) ANALYSIS OF INTELLIGENCE AND ACADEMIC SCORES AS A PREDICTOR OF PROMOTION RATE FOR U.S. ARMY NONCOMMISSIONED OFFICERS.

12 PERSONAL AUTHOR(S) WARNER, Jerry B.

13a TYPE OF REPORT: Master's Thesis

13b TIME COVERED: FROM ______ TO ______

14 DATE OF REPORT (Year Month Day): 1987 June

15 PAGE COUNT: 131

16 SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) ASVAB, AFQT, Promotion

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This thesis systematically and comprehensively analyzes available personnel data to determine if a significant relationship exists between measures of intelligence and academic performance, and career promotion rate for Noncommissioned Officers. Forty thousand Noncommissioned Officer (NCO) records were analyzed to determine this, using three approaches.

The first approach was a sequential procedure which progressed from analysis of individual variable through multivariate regression models. The second approach focused on analysis of NCO's who scored in the top three percent of promotion rate. The third approach used more advanced statistical techniques, including the use of principal components and factor analysis, to better identify the most influential explanatory variables.

(Continued)

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL: P.A. W. Lewis

22b TELEPHONE (Include Area Code): 408-646- 2283

22c OFFICE SYMBOL: 55Lw

DD FORM 1473, 84 MAR   83 APR edition may be used until exhausted. All other editions are obsolete.   SECURITY CLASSIFICATION OF THIS PAGE

Block 19. (Continued) ABSTRACT

During the analysis, eight measures of intelligence and academic ability were used as explanatory variables. Four control variables were included in the analysis to discriminate between subcategories of NCO's. They were: sex, career field, race, and paygrade.

Throughout the analysis consideration of Army promotion and accession policy was included. Knowledge of these policies resulted in elimination of some special groups which had received promotions under significantly different conditions than the rest of the sample. An example of this was Reserve and National Guard members called to active duty.

This study found that there was significnat statistical evidence to show that a high level of Armed Forces Qualification Test (AFQT) score and prior service academic accomplishment will correspond to a higher promotion rate. Also, in-service measures of NCO education and performance testing were good indicators of promotion rate.

However, there was significant variance associated with the explanatory relationship. As a result, a useful predictive model could not be designed using regression methods. Although the model could predict promotion averages for major population subcategories, it was unreliable when used solely with the AFQT variable.

The findings of this study suggest two policy recommendations. The first recommendation was a confirmation of the constraints placed on AFQT category and high school diploma status by the 1984 Defense Authorizations Act. The second recommendation was to require promotion boards to consider NCO schooling level and performance test scores in their proceedings, but to avoid directly tying either score to promotion, in terms of a minimum quota or scaled promotion point scale.

Finally, a suggestion was given for further research to investigate the underlying reasons for different attrition patterns observed among racial and ethnic groups.

Approved for public release: distribution unlimited.

Analysis of Intelligence and Academic Scores as a Predictor of Promotion Rate for U.S. Army Noncommissioned Officers

by

Jerry B. Warner
Captain, United States Army
B.S., United States Military Academy, 1976

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL
June 1987

Author: Jerry B. Warner

Approved by: P.A.W. Lewis, Thesis Advisor

Harold Larson, Second Reader

Peter Purdue, Chairman, Department of Operations Research

Kneale T. Marshall, Dean of Information and Policy Sciences

ABSTRACT

This thesis systematically and comprehensively analyzes available personnel data to determine if a significant relationship exists between measures of intelligence and academic performance, and career promotion rate for Noncommissioned Officers. Forty thousand Noncommissioned Officer (NCO) records were analyzed to determine this, using three approaches.

The first approach was a sequential procedure which progressed from analysis of individual variables through multivariate regression models. The second approach focused on analysis of NCO's who scored in the top three percent of promotion rate. The third approach used more advanced statistical techniques, including the use of principal components and factor analysis, to better identify the most influential explanatory variables.

During the analysis, eight measures of intelligence and academic ability were used as explanatory variables. Four control variables were included in the analysis to discriminate between subcategories of NCO's. They were: sex, career field, race, and paygrade.

Throughout the analysis consideration of Army promotion and accession policy was included. Knowledge of these policies resulted in elimination of some special groups which had received promotions under significantly different conditions than the rest of the sample. An example of this was Reserve and National Guard members called to active duty.

This study found that there was significant statistical evidence to show that a high level of Armed Forces Qualification Test (AFQT) score and prior service academic accomplishment will correspond to a higher promotion rate. Also, in-service measures of NCO education and performance testing were good indicators of promotion rate.

However, there was significant variance associated with the explanatory relationship. As a result, a useful predictive model could not be designed using regression methods. Although the model could predict promotion averages for major population subcategories, it was unreliable when used solely with the AFQT variable.

The findings of this study suggest two policy recommendations. The first recommendation was a confirmation of the constraints placed on AFQT category and high school diploma status by the 1984 Defense Authorizations Act. The second recommendation was to require promotion boards to consider NCO schooling level and performance test scores in their procedings, but to avoid directly tying either score to promotion, in terms of a minimum quota or scaled promotion point scale.

Finally, a suggestion was given for further research to investigate the underlying reasons for different attrition patterns observed among racial and ethnic groups.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

A. BACKGROUND

In almost any organization, one hopes that individuals at high levels of authority are gifted with higher than average intelligence. Correspondingly, one would think that, given equal work effort, a more intelligent person will advance more rapidly than his contemporaries in an organization.

It is not difficult, however, to find examples which contradict our perceptions of the role of intelligence in career advancement. In almost any field one can remember an individual who was not the most intellectually gifted, but through hard work and persistence, or other less quantifiable traits, advanced equally or better than persons of higher measured mental ability. There is ample room for other influences to overwhelm the value of a person's intelligence in the eyes of a superior. An unattractive personality, an inability to apply that intelligence to the tasks at hand, and a myriad of other flaws can discredit the merit of raw intelligence.

The degree at which intelligence impacts on advancement lies in the area of complex interaction between individuals and organizations. It carries with it much of the uncertainty of quantification of human performance.

Despite ample room for exceptions, the concept of a general reward for being more intelligent still seems reasonable. It may be, however, that to clearly see its manifestation requires looking at a large number of people who have been affected by as similar a set of opportunities for advancement as possible. It is the task of this thesis to investigate this relationship within a fairly restricted, but numerically large population. The population is one which has had fundamental raw statistics uniformly obtained, and where policies to promote personnel are unambiguous and well documented.

B. PURPOSE

The purpose of this thesis is to answer a central question: Does a significant relationship exist between measures of intelligence and academic ability, and an individual's promotion rate as a Noncommissioned Officer? Put more simply, does being smarter, as measured by initial test scores, or being better schooled, indicate that a person will perform better and, hence, advance more quickly than his peers?

The answer to this question has important implications for Army policies of recruitment, retention, and promotion. It is also a matter of general interest to social scientists.

C. ORGANIZATION

This thesis is organized fundamentally as a data analysis investigation. Chapters I and II provide preliminary information on the nature of the study variables, and briefly review some related articles which have addressed this topic. The remaining chapters discuss the analysis of approximately forty-thousand Noncommissioned Officer (NCO) records using three related approaches. The first approach is a fairly standard procedure of experimental data analysis. This procedure begins with analysis of fundamental attributes of individual variables, then advances through successive increases in dimensionality and complexity. The second approach views a subset of the population which distinguishes itself by being in the top three percent of the NCO promotion rates. Comparison of these top performers to the remainder of the population identifies attributes which are found to be significantly different, and hence, are possibly an associated cause for rapid advancement. In the third approach, the statistical methods of principal components and factor analysis are used to provide an alternative method of critical variable selection, as well as to lend credibility to the results of the other two approaches.

D. PRELIMINARY INFORMATION

This section contains an initial discussion about the nature of the data, a general overview of the Army NCO promotion system, and a synopsis of the analytical tools used in this thesis. As previously mentioned, there is a degree of looseness in the effectiveness of measurement for intelligence and academic data, and also some confounding phenomena in Army promotion policy. Early recognition of these problems should set the degree of caution which is needed in reviewing the subsequent chapters of analysis. The section on analytical tools is intended to inform the reader of the conditions under which the data analysis was conducted, and the hardware and software used.

1. Intelligence Test Scores

a. General

The data for intelligence test scores falls into the category sometimes referred to as Defined Measurement. A Defined Measurement is one where the property being considered cannot be measured directly.[Ref. 1 :p. 6] As a result, a related measure is substituted for measurement of the actual property. In this case, the property is intelligence, and the presumed related measurements are test scores from a particular battery of tests.

The efficacy of intelligence tests as a representative measure for intellectual ability is itself an issue surrounded by controversy. This controversy has been the topic of entire books and studies. The testing done by the Army is the Armed Forces Vocational Aptitude Battery, or ASVAB. Although not designed specifically as an intelligence test, the ASVAB does predict general trainability. Additional research has shown that the mathematical and verbal portions of the ASVAB have a high correlation to the ACT, PSAT, and SAT college entrance examinations.[Ref. 2] The ASVAB has been studied, improved, and used for over forty years. A recent article by Jenson [Ref 3:p. 35], in Measurement and Evaluation in Counseling and Development, states:

> "To the degree that success in various occupations and training programs requires different levels of general ability (often called intelligence or IQ), an ASVAB composite (it hardly matters which one) will be as validly predictive as any test now on the market. . . It seems that the new ASVAB-14 is near the limit of refinement, psychometrically."

Generally then, the ASVAB is a well documented and established aptitude test. Although the military does not specifically attempt to determine the intelligence of its potential candidates, academic portions of the ASVAB test have shown themselves to be reasonably defined measurements of intelligence.

b. Specific Tests.

The ASVAB consists of a battery of ten subtests. Composites of the subtests of the ASVAB are used to determine the overall acceptability of an individual requesting enlistment, and for which field he or she would best be suited. From the entire battery of tests, two derived scores of intelligence are taken as aggregate measures of intelligence. The first is the GT, or general intelligence score. This score is the aggregation of three submodules, the word knowledge, paragraph comprehension, and arithmetic reasoning. The second derived measure of intelligence is the Armed Forces Qualification Test Score, or AFQT. This score considers four submodules, word knowledge, paragraph comprehension, arithmetic reasoning and numerical operations.[Ref. 10:sec 1-0, p. 1] An AFQT score is reported as a percentile score representing the examinee's relative standing in reference to a specific population.

There has recently been some additional manipulation of the AFQT score. In October of 1984, the reference population for assignment of an individual's AFQT percentile was shifted from a base reference population of 1944 to that of 1980. A base reference population is a set of values designed to represent how the raw AFQT scores of the entire American youth population would be distributed. This set of values was originally designed in 1944, and had not been updated until 1980. This thesis utilized the 1980 base AFQT percentiles. A transformation of test percentiles for soldiers who enlisted prior to 1980 was effected by the Defense Manpower Data Center (DMDC), and all subsequent Department of the Army records have been computed based on the 1980 reference. A listing for AFQT percentile transformations can be found in APPENDIX A.

GT scores, which are expressed as the sum of the raw test scores, have not been manipulated. However, unlike the the case with AFQT score, soldiers have been allowed to retake their tests to increase their original GT scores. Retesting was introduced in 1982 when a minimum GT score of 120 was enforced on eligibility for promotion to NCO rank.

2. <u>Academic Scores</u>

a. General

The data used for academic ability is also a defined measurement, similar to the measures for intelligence. Specifically, the property of academic ability is being represented by a simple assignment of the number of years This value is independent of the quality of education, and the grades that any given individual may have received. This study assumes that continued attendance and progression through the educational system is inherently indicative of academic ability. For example, a high school graduate has more academic ability than an individual with an eighth grade education. The informational value of academic scores is thus, not as useful as desired. It is treated in analysis as only an ordinal scaled variable.

b. Specific

Three academic scores are used in the study: present education level, education level upon entry into Army, and military education since entry. Because advanced professional schooling is made available only to those individuals who have superior service records, the military education score carries with it some additional information relative to the performance of the NCO.

3. <u>Promotion Scores</u>

Promotion within the Army is a closely supervised and somewhat complicated procedure. It is the product of a considerable number of policies which are not uniformly applied across the population. Instead, they are applied within rank structure, within career field, or even as a function of years of education. Thus, although the computation of an individual's promotion rate is an easy task, that value may have been influenced by several policies that were peculiar to the individual.

a. General

Promotion of NCO's is governed by Army Regulation AR 600-200. This regulation establishes requirements for eligibility, and outlines the process of selection. The system views the individual's performance as a whole. This includes a composite score based on performance scores, commander's ratings, service awards, and review by a board of senior NCO's. This composite point value is used as a threshold value for the Department of the Army to use when promoting individuals to the next higher paygrade, as slots become available. The slots are accounted for by career management field, and as such, the minimum threshold for a combat soldier to be promoted may be different than that of a support soldier. A general observation is that career fields with more technical orientation have higher promotion point thresholds, and subsequently, longer times to advancement than those in the larger and less technically oriented career fields.

AR 600-200 also sets minimum times of service and grade which an individual must have served to be considered for promotion. Unless superceded by a special policy, the shortest period for promotion to E-5 is two years, and is four years to E-6. This rate includes waivers for both time in service and time in grade. Promotion to E-6 in four years requires that the individual be advanced to E-5 in two years.

b. Specific

Because of the lack of uniformity of promotion within the army population, in this thesis we have taken considerable care to identify and address discontinuities which would confound promotion based on merit. This includes the elimination of some data, and the computation of three different promotion rate scores. The governing principle for manipulation or restriction of data was to produce a sample population in which each individual started from the same point in the rank structure, and had equal opportunity for advancement by merit. Chapter III, Overview of the Data, discusses in detail the identified problems and what corrective action was taken.

4. <u>Analytical Tools Used</u>

This section briefly identifies the hardware and software used in analysis.

a. Hardware

Computational resources used for analysis included an IBM 3033 System 370 mainframe computer running MVS batch system. Additionally, analysis was done for small data sets using a standard IBM microcomputer.

b. Software

Two software packages were used for the majority of the data analysis. <u>SAS Version 5</u> was used predominantly for analysis resulting in tabular output, such as principal components and factor analysis.[Ref. 4,5] <u>Grafstat</u>, an unreleased IBM mainframe data analysis and plotting program, was utilized for analysis requiring graphical output and for confirmation of SAS tabular results.[Ref. 6,7]

E. SUMMARY

The objective of this introduction has been to adequately frame the scope of the topic, and to present sufficient background to the reader so that he or she is alerted to some of the difficulties inherent in a topic of this nature. Also, this will establish a reference for some of the tools used to conduct the analysis.

The length of this section is indicative of the degree of preparation required to analyze a relationship which has significant complications in both dependent and independent variables. Although the list of assumptions and the stripping of aberrant data makes one cautious about the reality of such a study, each event should be considered on its ability to uncover the answer to the central question of this thesis. The central question again is, whether or not a significant relationship exists between measures of intelligence and academic ability, and an individual's promotion rate as a Noncommissioned Officer. It is important to learn whether measures of intelligence and academic ability are important indicators of promotion in the army, and if so, how strong that relationship is. If sufficiently reliable and believable relationships can be determined, then policies could be designed to better identify and develop capable individuals for positions of leadership.

The analysis of this thesis reduced the effects of confounding policies, such as discriminatory promotion and accession programs. It also used a sufficiently large sample size, which allowed the averages to outweigh the exceptions. It drew on data from standard personnel records, and made the most effective use of that information.

II. A REVIEW OF PREVIOUS STUDIES

The topic of relating intelligence to some aspect of performance is an extensive and rich area of study. It is a particular topic of interest to social scientists and military manpower specialists. As a demonstration of the quantity of work done in this area, a simple cross-referencing of the words intelligence test and performance produced a list of 237 citations from the Lockheed's DIALOG online information files. Restriction of available references to those utilizing military intelligence test scores and statistical analysis of those tests relative to some performance measure still results in a large number of citations. Within this restriction there is a variety of study methodologies. The source of a study can originate from an in-house military analysis, a contracted study done by a commercial analytical institute, or an academic institution making use of military data as its media for analysis.

The nature of the data is also varied. Several studies readministered the ASVAB tests to a selected test population, other studies used IQ and other intelligence measures in addition to the ASVAB. The performance side of the relationship had an extensive number of dependent variables. Examples of performance measures were: results of written exams, military skills test results, minority advancement, and comparison to collegiate ACT, PSAT, and SAT tests.

This chapter will review four of the most closely related studies, concentrating for each one on:

1. The objective of the study.
2. The methodology used in analysis.
3. The conclusion reached.

The first analysis is from Are Smart Tankers Better? AFQT and Military Productivity.[Ref. 8] This study is essentially an in-house military analysis, the authors being Army officers assigned to the Office of Economic and Manpower Analysis, at West Point, New York. As described in the title, the paper presents the results of an investigation in which the crews of tanks were scored on their ability to destroy targets on live fire ranges. The AFQT score of the gunner and tank commander was one of several explanatory variables, having the tank scores as the dependent variable. The analysis methodology used a log-log production model with ordinary least squares regression.

The result of their analysis is best summarized in this paragraph from the study:

> "That there exists a positive, statistically significant relationship between AFQT and performance, is a powerful result. The coefficients on the model means that if we move, for example, from the AFQT score for an average Category IV TC to the AFQT score for an average Category IIIA TC, (a 200% increase), we will increase the performance on Table 8 (the tank scoring exercise) by approximately 20.3%."

In this study then, AFQT was found, by means of least squares regression, to have a definitive relationship to a well-defined skill measure, the conduct of tank firing.

The second study is an analysis done at the University of Iowa by the Cada Research Group titled: On Predicting Success in Training for Males and Females; Marine Corps Clerical Specialties and ASVAB Forms 6 and 7.[Ref 9] This report uses the ASVAB score as an explanatory variable for success of recruits in training. The methodology used is primarily regression; however, the scope of the regression concentrates on identifying differences between male and female performance. The implicit result in the study's discussion of the sex score differences is that the regressions performed for each category was of useful predictive value. An interesting note about this study was that the inclusion of high school completion reduces the difference between the male and female regression coefficients.

The third study is a section of articles used in the Report to the House and Senate Committess on Armed Services, Defense Manpower Quality, Volume II, Army Submission. [Ref. 10] The section of interest to this thesis was a study done by the U. S. Army Training and Doctrine Command (TRADOC) Systems Analysis Activity (TRASANA). The study uses AFQT, as well as education level, sex, paygrade, time in service, time in Military Occupational Specialty (MOS), and a dummy variable reflecting General Equivalency Diploma (GED) completion as explanatory variables. GED is a rating given to individuals who did not graduate from high school, but who have taken examinations to be rated as equivalent to a high school graduate. A battery of tests given under controlled conditions resulted in a net score which was made the dependent variable. The battery of tests was designed so as to represent how proficient a soldier was in his specific career field. The test included a written, as well as hands-on proficiency test.

The analysis method used was linear regression, with the inclusion of a Durbin Instrument as a correction tool for AFQT. The results are again best summarized from the report:

> "The most important result is that AFQT Category I-IIIA soldiers performed approximately 10% better overall than IIIB soldiers. . . Furthermore, AFQT was a much more important influence on performance in virtually all instances than either education or experience, whether measured in terms of time in service, MOS, or unit. Thus, these results strongly support the validity of AFQT as a predictor of performance in these military occupational specialties."

This report then, is very similar in conclusion to the tank gunnery report, in which AFQT was shown through regression to have a significant and measurable effect on soldier performance in skill related tasks.

The last study reviewed is also from the collection found in the Defense Manpower Study. [Ref. 11] The topic for this study was the estimation of promotion rate. It is presently the most similar study to the central theme of this thesis.

Using AFQT as one of the independent variables, a duration model is applied to estimate the expected speed of promotion. This model was applied within two categories, the paygrade and the career field of the NCOs. This promotion estimation study approaches the aggregation of data in a different manner as well. Specifically, by evaluating the possibility of promotion for each individual over a series of years, the dimension of time was entered into analysis. A significant advantage of including the time dimension was that changes in the categorical levels of the population could be accounted for, such as race or sex.

The methodology used in the promotion estimation study is considerably more complex than in the previous studies. Rather than using standard regression models, the study uses the Generalized Linear Model form. Specifically, the form of the predictive model is a log likelihood function using the Weibull shape parameter. The explanatory variables include education, AFQT, marital status, race, number of dependants, time in service, sex, and high school completion status. By using the Weibull model, the application of explanatory variables which are not continuous, such as sex, high school completion status, and marital status is more proper. Additionally, there are no requirements for the normality assumptions for the residuals, and therefore, less subjectivity to the appropriateness of the model with respect to the independent variables. This method, however, does not consider any in-service information and was calculated only for very specific CMF and Paygrade combinations. The results are summarized as follows:

> "A review of these promotion results reveals two trends. First, even after controlling for high school diploma status, AFQT Category I-IIIA soldiers are promoted approximately 10% more rapidly than IIIB soldiers. Second, high school completion is less important than AFQT score in determining promotion rates. The remarkable aspect of this last result is that educational attainment is an explicit part of the Army's promotion point system, while AFQT scores are not. These trends are true for both promotion to E-5 and promotion to E-6."

As considerable attention has already been given to the topic of relating measures of intelligence to performance, and since positive results have generally been the result, one might wonder why another study should be undertaken. First, this thesis is in response to a request by the Office of the Deputy Chief of Staff for Personnel (ODCSPER) for further research in the relationship of AFQT to success in the Army. Secondly, this thesis will be different in its approach and analytical procedures. Following is a list of the unique characteristics of this thesis:

1. The perspective of this thesis is that the results will be used as a management tool, or as an explanatory method for active duty Army personnel. In that light, the study utilizes information collected from the individual's in-service record, such as his Skill Qualification Scores, and his NCO Schooling levels. Similar to accession related studies, this analysis includes intelligence, academic, and categorical information as potential explanatory variables. However, the intent is not to justify accession of high quality soldiers, but to investigate the trends of promotion for active duty personnel as a function of available personnel data.

2. This study conducts significant investigation into the data to identify and correct anomalies which would confound the relationship in question.

3. Statistical analysis is done from the bottom up, rather than by direct movement into regression models. This approach finds that strict parametric models are subject to error due to the inability of some data variables to meet distributional assumptions necessary for parametric analysis. The study then moves to nonparametric means to approach the issue.

4. For regression models, given the cautions on their use, an additional sample population is tested using the model. Thus, the results from the initial model can be considered to have more believability and fidelity than a model based on analysis of a single population sample.

5. The use of a large data set.*

6. Several explanatory variables have been made available from the DMDC data base which have not been used in previous studies. They include the initial education at time of entry, NCO education level, and a race variable with six categories.

7. The choice of promotion as the dependent variable rather than a set of performance tests. Although prone to more uncertainty than results of performance tests, promotion is in many ways an ultimate performance measure. The service, like any other organization, recognizes superior performance by promoting and advancing individuals to higher positions of authority. As such, promotion rate, despite its problems, has a strength of recognition well beyond that of technical performance.*

8. This study uses graphical methods for depiction of many of the methods of analysis.

---

*Study number four from Defense Manower Study uses both large data sets and promotion as an independent variable.

III. OVERVIEW OF THE DATA

A. INTRODUCTION

A critical aspect of this thesis was the selection and screening of data. Two general guidelines were applied in creating the data set. First, the data set had to demonstrate a level of homogeneity in that the NCO's considered would all have served under similar enlistment and advancement policies. Secondly, the selection of individual records needed to be random and without unintentional bias to meet the requirements for a representative sample set. Section III C. describes in detail the measures taken to insure that the above two attributes were established in the study data set.

Recoding of data values into numerical equivalents was required for several personnel record fields. As an example, the level of Military Schooling, which is the NCO's in-service schooling level, was recorded as mixed alpha-numeric characters. Transformation involved rank ordering the available levels of schooling in ascending hierarchical order and substituting a numeric value for the alpha-numeric value. Chapter IV discusses in detail the background of each variable. Finally, as a check on the effects of manipulating and restricting the sample data set, section III D. provided a comparison of statistics for the entire U.S. Army NCO database, versus the sample data set used in this thesis.

B. DESCRIPTION OF THE VARIABLES

The data variables used in this study fall into three categories: control variables, intelligence variables, and promotion variables. The first two categories, control and intelligence, were used as explanatory variables, while the promotion variables were used as the dependent variables. A brief description of each variable is tabulated in Table I.

TABLE I Summary of Variables in Sample

Variable	Category	Meaning	Value	Scale
Dependent				
PRATE	Promotion	Raw Promotion Rate: number of promotions per month to most recent promotion	.041-.21	Ratio
RATE	Promotion	Promotion rate difference from average for that paygrade (normalized)	-2.2-9.4	Ratio
PRA	Promotion	Promotion rate difference from average for that paygrade and CMF (normalized)	-3.4-8.0	Ratio
Explanatory				
SEX	Control	Male/Female	0/1	Nominal
CMF	Control	Career Management Field	11-99	Nominal
RACETH	Control	Race/Ethnic group	1-5	Nominal
PAYGD	Control	Paygrade	5-7	Ordinal
GTSCR	Intell	General Intelligence Score	0-160	Ordinal
AFQTP	Intell	Armed Forces Qualification Test Score Percentile	1-100	Ordinal
OAFQTP	Intell	Same as AFQTP, referenced on 1980 population	1-100	Ordinal
EIMCAT	Intell	Mental Category; based on OAFQTP	1-8	Ordinal
HIYRED	Intell	Highest Year of Education upon entry into Army	1-12	Ordinal
EDLVL	Intell	Present Education Level	1-12	Ordinal
NCOE	Intell	Military Education Level Attained	0-13	Ordinal
PQSCR	Intell	Army Proficiency Test	0-100	Ratio

A more detailed description of each of the study variables will be given in the first part of Chapter IV, Successive Analysis.

C. PREPARATION OF THE DATA

Preparation of the data began with acquiring fifty thousand records from the U.S. Army Military Personnel Center in Alexandria, Virginia. Initial restrictions on the data were established to allow inclusion of only NCO's with a date of entry after January 1, 1976. Further, NCO's selected had to be members of the Regular Army, and not Reserve or National Guard forces. These restrictions provided for observation of only those NCO's who were recruited a reasonable time period following the ending of the Viet Nam War, and following the establishment of the All-Volunteer Force. Restricting the NCO's to Regular Army soldiers focused the study on the standing forces alone, and avoided confounding as a result of different promotion and accession policies in the Reserve and Guard Forces.

The records requested were randomly drawn by taking every fifth individual from an estimated population of 250,000 meeting the above restrictions. The fifty thousand MILPERCEN records were then matched and merged with a similar personnel database from the Defense Management Data Center (DMDC) Monterey, California. The DMDC database holds additional information, including: the ability to distinguish high school equivalent certificates holders from actual graduates, the highest year of education of the soldier at time of enlistment, and AFQTP and EIMCAT scores renormed for a 1980 population.

After the merging, data records which had missing values in any of the critical variables fields were dropped. There were approximately ten thousand records missing critical data. Following initial analysis of promotion rates, two additional restrictions were applied against the remaining records.

First, a grouping of several hundred promotion rates showed that individuals had been promoted to the rank of E-5 at rates which were as high as one promotion per month. Cross referencing of service numbers identified this sub-group as NCO's who had served in Reserve or Guard units and who, for a variety of reasons, had been called for active duty. As such, they were allowed by regulation to carry with them an accelerated promotion to their former rank. Subsequently, a serial number match and elimination was done for all NCO's with recent listing as Reserve or Guard status.

A second source of unusual promotion rates at the E-5 level became apparent in some of the more technically oriented career management fields, the medical field in particular. Research into Army special recruitment policy indicated that during the early 1980's special provisions were made to allow persons with background ability in certain technical fields to enter the Army and be promoted to NCO status within six months, or in certain cases to receive NCO status immediately following basic training.[1] To correct for these anomalies, all promotion rates which fell outside the maximum time periods considering application of both waivers were discarded.

D. COMPARISON TO TOTAL ARMY STATISTICS

In this section, selected attributes of the sample data set and the complete U.S. Army database are briefly compared, with the intent of checking the representativeness of the sample set.

Population attributes such as distribution of sex, Career Management Fields, and paygrade were obtained from the complete U.S. Army database records consisting of over 250,000 NCO's.

As described in paragraph 3.B, the sample data set of 50,000 selected records had been filtered to contain only personnel who entered the Army after 1976. Screening of those 50,000 records for completeness of data and uniformity of promotion policy, reduced the number in the sample set to approximately 38,000. It was prudent then, to check the final sample set to see if it retained its representative character as a random sample. It should be noted, however, that this comparison will not occur for all study variables.

---

[1] MSG Knopp, NCOIC Defense Management Data Center, West. El Estero Drive, Monterey CA 93946.

Reasons for this include non-availability of records from the MILPERCEN database, and cases where the statistic was produced through computation by the author, promotion rates being the principal example.

1. Comparison of Army versus Sample Summary Statistics

Formal hypothesis testing for means or distributions with ANOVA was unavailable due to computational and software restrictions. However, since the intent of this section was simply to identify any population shifts, and the magnitude of those shifts, observation of summary statistics is assumed to be sufficient. Specifically, the means and the standard deviations of four variables were obtained from both the entire NCO population data set and the thesis sample data set. The percent difference between the variable means was computed and expressed relative to the thesis sample data. A table of comparative statistics and the percent difference is shown in Table II.

TABLE II Total Army vs Sample Summary Statistics

	Total Army		Sample		
Sample Size	(250,000)		(37,854)		Percent
Variable	Mean	Std Dev	Mean	Std Dev	Difference
AFQTP	48.3	25.2	53.4	20.9	Sample 10% >
SEX	1.09	.283	1.12	.328	Sample 2.7% >
RACETH	1.63	.991	1.65	.942	Sample 1.2% >
PAYGD	5.75	.597	5.27	.464	Sample 5.2% <

The three variables AFQTP, SEX, and PAYGD have noticeable changes between the Sample and the Total Army, while the RACETH variable doesn't appear to have been affected much by sampling. A closer look at the discrete distributions, and an overall conclusion about differences in the two data sets follows.

2. Discrete Distributions

Figures 3.1 and 3.2 illustrate differences in the discrete distributions for paygrade and race respectively. Both plots are Clustered Bar Charts, and the percentage of each level of the discrete variable for both the Total Army and the Sample were plotted next to each other.

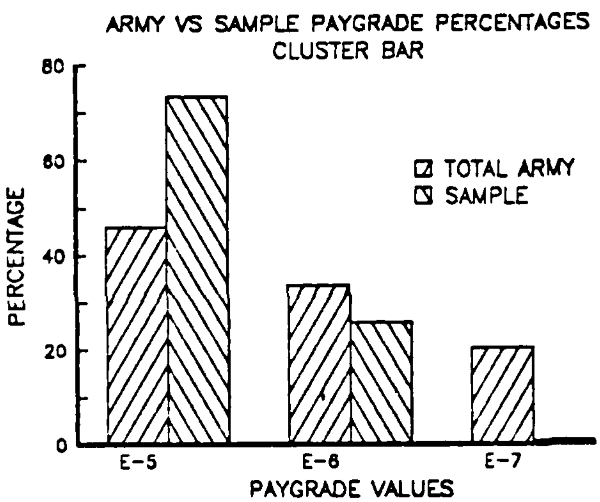


Figure 3.1

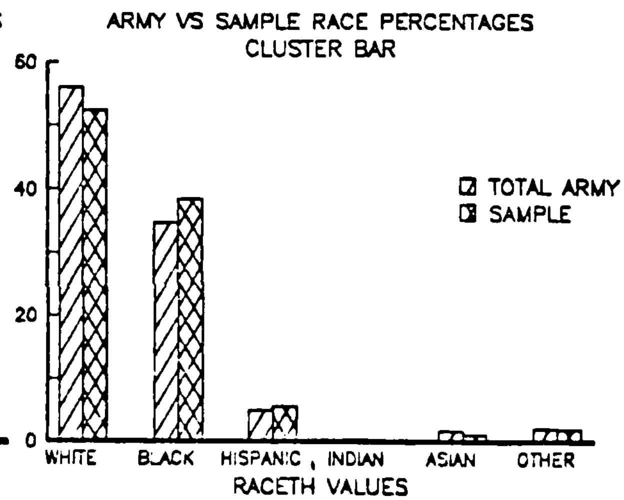


Figure 3.2

Observation of the tabular data and bar charts show that there are some differences between the two populations. Specifically, the sample contains more lower ranking personnel, slightly more women, and significantly higher AFQTP related scores. The racial make-up of the sample appears to be similar.

The restriction of random sampling to only those persons entering the service after 1976 can directly or indirectly explain these differences. First, the lower average paygrade is a direct result of promotion policy, in which it is impossible to achieve a rank above E-7 in less than ten years. Hence, the sample population should be demonstrate a lower average paygrade. Secondly, the slight increase in the proportion of women might be explained by a general opening up of the services to women in the late seventies and early eighties. Thirdly, the higher AFQTP is a direct result of policy restrictions begun in Fiscal Year 1981, and formalized by the 1984 Defense Authorization Act. This placed quality constraints on AFQT Category and high school diploma status. [Ref. 10:sec 1-0, p.1] Whether these restrictions, or the general improvement of social acceptance of the military services resulted in this AFQT improvement is a question which would require significant study in itself.

In short then, the sample is different in several ways from the total NCO population. It should be noted, however, that these results are intentional. The shifts caused by restricting the sample to after 1976 are felt to be less dangerous to the study than the alternative of including soldiers who were accessed during the draft and the era of Viet Nam War policies. Finally, it is only a matter of time, unless significant changes in accession and promotion policy occur, before the character demonstrated by the sample data set will constitute the norm for all NCOs. Thus, it is concluded that the study sample is satisfactory.

IV. SUCCESSIVE DATA ANALYSIS

A. INTRODUCTION

In this chapter the results of a systematic method for data analysis will be reported. This method of analysis followed a format which is described by Chambers in Graphical Methods for Data Analysis.[Ref. 12] This procedure develops an understanding of the data, beginning with simple univariate descriptive procedures, then progressing through several increases in dimensionality of variables, and finally into the more complex inferential procedures of model building and multivariate regression. An abbreviated outline of this procedure is shown below.

1. Analysis of single variables.
2. Comparison of variable distributions.
3. Analysis of paired variables.
4. Multivariate graphical analysis
5. Linear Models including:
   a. Simple Regression
   b. Multivariate Models

In addition to these steps, this procedure will be supplemented with several non-graphical measures, such as ANOVA, ANCOVA, and several tabular nonparametric methods. It should be noted that this analysis reports only those procedures which are considered an essential step in investigation, or whose results provided an observation of merit. Many available procedures have not been used in this chapter, as a consequence of the data failing to meet distributional assumptions, and for other reasons which would make such analysis inappropriate. During the development of this chapter, the results of each level of analysis will specify why the next set of analysis procedures was pursued. Alternatively, if a popular class of procedures is disregarded, the logic for disregarding is explained.

The objective of detailing this procedure is to present a thorough depiction of the nature of the variables, and to explain the development of resulting inferences and models.

B. UNIVARIATE ANALYSIS.

1. Dependent Variables

a. PRATE

(1) General. The variable PRATE represents the raw promotion rate of a particular individual. Numerically, it is the total of promotions per month up to the most recent promotion.

(2) Value. The variable PRATE was computed using data obtained from the DMCD database. The time to most recent promotion in months was found by subtracting the basic pay entry date from the date of latest award of rank. This number then became the denominator of a ratio having the individual's rank, or equivalently, the total number of promotions the individual has received, as the numerator:

$$\text{Prate} = \frac{\text{Individual's Latest Rank}}{\text{(Award Date of Latest Rank)} - \text{(Date of Entry in Army)}}$$

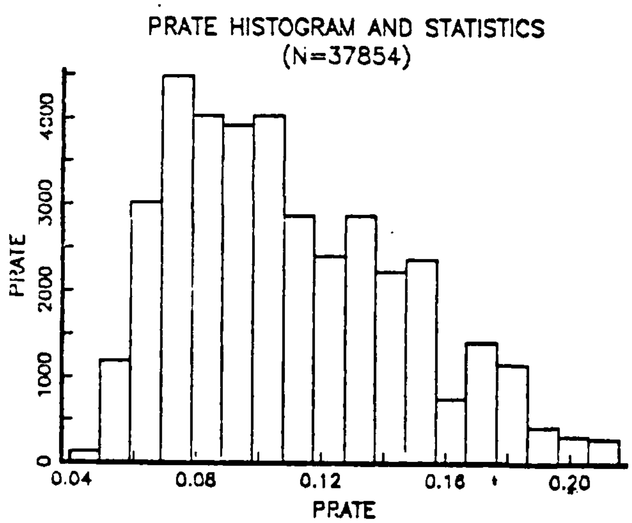
Ranks were numerically represented with a score of 5 for an E-5 Sergeant, and with 6 and 7 for values of the next two ranks. The resulting units of measurement for the PRATE variable were: units of promotion per month of service.

(3) Attributes of the Variable. The variable PRATE qualifies as a continuous variable with a ratio scale. The continuous nature of the variable relies on the fact that the number of months service combined with three rank structures yields sufficient combinations of values, actually 190 in all, to use as measures.

There are some inherent problems with the raw PRATE score, since promotion policies are in effect which set minimum time thresholds for promotion. Thus, the promotion of an individual who is presently an E-5 will be incomparable to the promotion rate of an E-7 whose three promotions have been affected by the minimum time policy. Generally, the minimum time in service between promotions grows as rank increases, and more senior soldiers will normally have lower raw promotion rates.

A second source of bias is potentially found in the Career Management Field (CMF) of the soldier. Army promotion policy is based on a system of minimum performance points to be attained within a CMF in order to be considered for promotion. Generally, the more technical fields will have higher promotion point thresholds than non-technical fields.

The distribution of the variable PRATE and its summary statistics are shown in Figure 4.1. The shape of the histogram is positively skewed, demonstrating a steep ascending slope in the first partitions, then a generally flat shape until just past the median value. After the median value, a gradual downward sloping tail occurs. A rough interpretation of this shape is that there appears to be a few individuals who are promoted at very fast rates, followed by a block of average promotion rates, then a diminishing tail of individual promotion rates which fall to the right of the seventy-fifth percentile.



HISTOGRAM TABLE

X	:PRATE
SELECTION	:ALL
X LABEL	:PRATE
NO. OF ELEMENTS	:37854
X MEAN	:0.10948
STD. DEVIATION	:0.036322
SKEWNESS	:0.59367
KURTOSIS	:2.5854
5-PERCENTILE	:0.061225
25-PERCENTILE	:0.08
MEDIAN	:0.10204
75-PERCENTILE	:0.13514
95-PERCENTILE	:0.17857
X MIN.	:0.041667
X MAX.	:0.20833

Figure 4.1

Distribution transformation of this variable was not attempted, primarily because its usefulness in testing or modelling is limited by the problems associated with the bias factors described above.

b. RATE

(1) General. The variable RATE is a re-expression of the variable PRATE. It has bias due to individual rank removed by normalizing each individual score relative to his or her paygrade.

(2) Values. To compute the variable RATE, the average PRATE value for each paygrade was calculated, as well as the standard deviation for that paygrade. Individual scores were then normalized by the transformation:

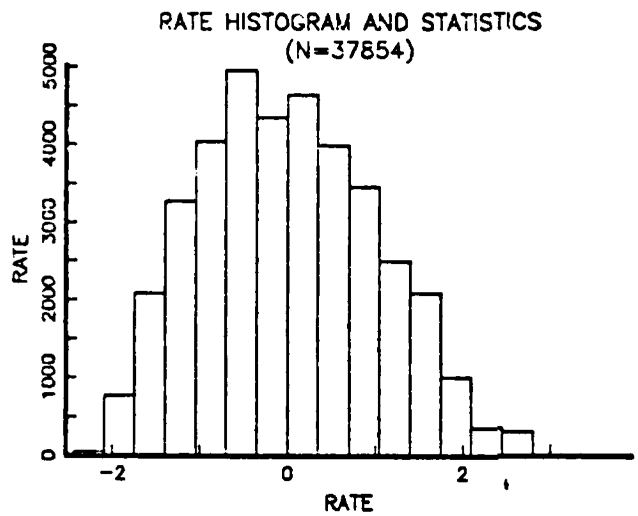
$$RATE_i = \frac{PRATE_i - \text{AVERAGE for that Rank}}{\text{STANDARD DEVIATION THAT RANK}}$$

(3) Attributes of the Variable. The variable RATE is also a continuous ratio scale variable, as it is a transformation of PRATE.

The removal of influence due to rank was confirmed by computing the correlation coefficient between the variables RATE and PAYGD. As seen in Table X, a value of near zero resulted where the previous correlation coefficient for PRATE and PAYGD had been -.495. Thus, the transformation to RATE from PRATE results in a variable independent of PAYGD.

The distribution shape of the RATE histogram, shown in Figure 4.2, appears slightly non-normal, but a check of the summary statistics for quantiles show that they correspond closely to the standard normal quantiles. Thus, the assumption of normality for procedures using this variable is still reasonable, based on observation of the distribution shape and the close agreement of quantile values.

Figure 4.2 presents a histogram and summary statistics for the RATE variable.



HISTOGRAM TABLE

X	:RATE
SELECTION	:ALL
X LABEL	:RATE
NO. OF ELEMENTS	:37854
X MEAN	:¯1.565E¯6
STD. DEVIATION	:0.99997
SKEWNESS	:0.21408
KURTOSIS	:2.3767
5-PERCENTILE	:¯1.5476
25-PERCENTILE	:¯0.77578
MEDIAN	:¯0.03757
75-PERCENTILE	:0.70754
95-PERCENTILE	:1.6234
X MIN.	:¯2.2681
X MAX.	:3.6685

Figure 4.2

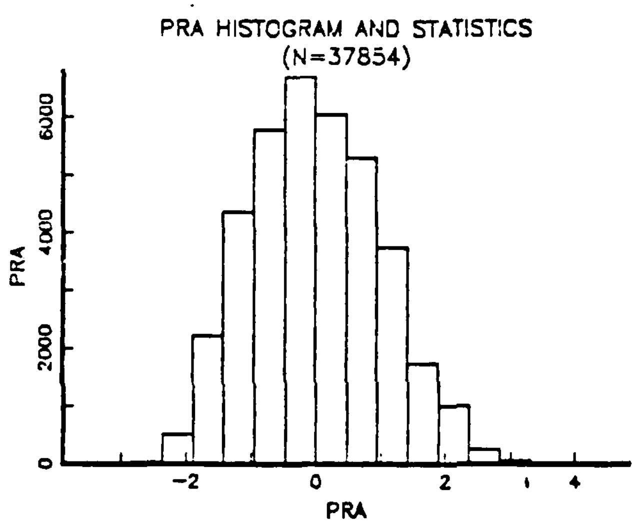
c. PRA

(1) General. The variable PRA is another recomputation of the raw promotion rate. PRA controls for the career management field as well as paygrade. It is set of normalized promotion scores, which are independent of PAYGD and CMF. Verification of the independence of PRA from these variables was also confirmed by checking correlation coefficients. Both variables CMF and PAYGD had near zero values of correlation with PRA.

(2) Values. Computing the variable PRA was done in the same manner as in RATE, however a mean and standard

deviation for each CMF and PAYGD combination was computed and used in the normalization equation.

(3) Attributes. PRA is a continuous variable with a ratio scale. The distribution of PRA appears normal, with the quantile values very close to the standard normal. A comparison of percentile values for PRA versus the standard normal are shown in TABLE III.



HISTOGRAM TABLE

X	:PRA
SELECTION	:ALL
X LABEL	:PRA
NO. OF ELEMENTS	:37854
X MEAN	:7.41E¯9
STD. DEVIATION	:0.99881
SKEWNESS	:0.21406
KURTOSIS	:2.6652
5-PERCENTILE	:¯1.5518
25-PERCENTILE	:¯0.75252
MEDIAN	:¯0.04146
75-PERCENTILE	:0.69604
95-PERCENTILE	:1.7086
X MIN.	:¯3.4988
X MAX.	:4.5374

Figure 4.3

A comparison of percentiles for the PRA distribution versus the standard normal distibution is shown in Table III. Specifically, the PRA percentile values are listed with the corresponding standard normal percentile values for the same data point. For example, -1.5510 is the PRA five percentile, while a -1.5510 indexed in a standard normal table results in a six percent value.

TABLE III. Comparison of PRA vs Standard Normal Percentiles

PRA	Standard Normal
5%	6%
25%	22.6%
50%	48.4%
75%	75.7%
95%	96.3%

Normality for this variable will be assumed based on general distribution shape and the close correspondence of the data percentiles to the standard normal percentiles.

2. Control Variables

d. SEX

The variable SEX is discrete and nominal. Males are represented by a numerical value of one, and females are represented with a two. In the study sample, 12.29 percent of the sample was female, and 87.71 percent were male.

e. CMF

Career Management Field (CMF) is a discrete variable with nominal scale. Thirty three CMF's are represented in the sample. Each Career Management Field is assigned a numerical value, for example, the Infantry branch is designated as CMF 11. These assignments are a Department of the Army numbering system, and can be reviewed along with the CMF percentage and frequency table in Appendix A.

There is some ordinal information in the numbering system, for instance, low CMF numbers are indicative of a combat branch, such as Infantry or Armor. Center CMF values are indicative of combat support branches, such as Signal and Chemical. Upper CMF values are from the combat service support branches, such as Medical and Language Specialist.

Figure 4.4, the CMF histogram, does reflect the distribution of the three general groupings of CMF densities: combat, combat support, and combat service support. The combat and combat support values have roughly equivalent representation, while the upper numbered service support CMF's are about two thirds the size of the other groups.

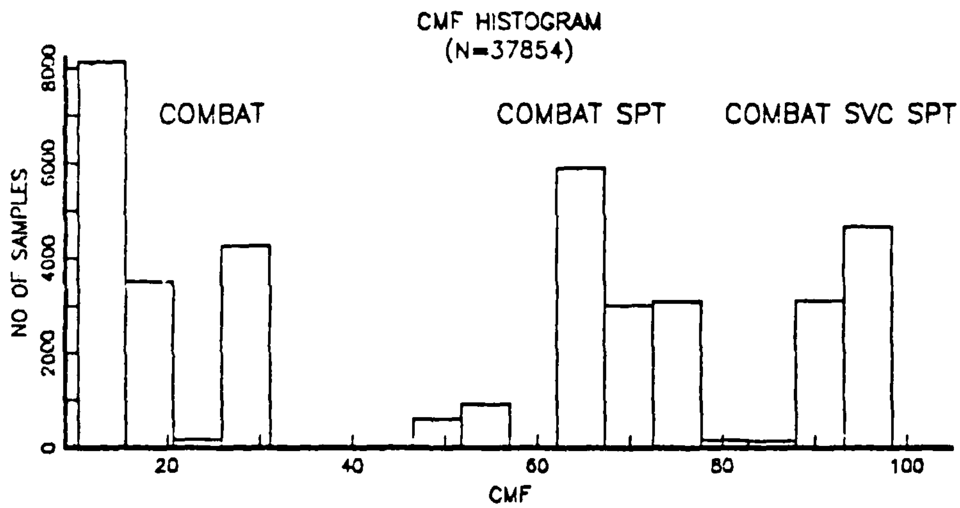


Figure 4.4

f. RACETH

The race-ethnic variable is a discrete, nominal variable. The values represented and their percentages are shown in table IV.

TABLE IV Sample Race Percentages			
Value	Race	Percent	Cumulative Percent
1	White	52.43	52.43
2	Black	38.59	91.02
3	Hispanic	5.58	96.6
4	American Indian/Alaskan Native	.26	96.86
5	Asian/Pacific Islander	1.15	98.01
6	Other/Unknown	1.99	100.00

g. PAYGD

Paygrade is a discrete, nominal variable. The selection of NCO rank from personnel enlisting after 1976 resulted in representation by paygrades E-5 through E-7 only The distribution of PAYGD is shown in Table V.

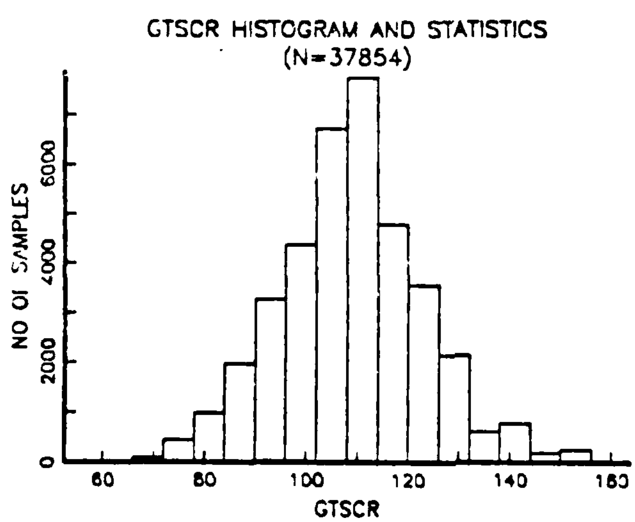
TABLE V Sample Paygrade Percentages			
Value	Rank	Percentile	Cumulative Percent
5	Sgt E-5	73.29	73.29
6	Staff Sergeant E-6	25.89	99.19
7	SFC E-7	0.81	100.00

The 0.81 percent for E-7 results in only 307 SFC's in the sample. Despite the preponderance of representation by the other ranks, a sample size of 307 for the E-7 rank still allows for adequate representation of that subcategory.

3. Intelligence and Academic Scores

h. GTSCR

The General Intelligence Test Score (GTSCR) of the individual is a continuous variable with at least an ordinal scale. The range of values run from 50 through 160. The lower value of 50 represents the corresponding minimum score of ASVAB modules that would allow for enlistment in the Army. The histogram of the GTSCR variable, shown in figure 4.5, is approximately normal. Checking the quantiles shows a larger density in the distribution to the left of the mean, with slightly lower values for quantiles right of the mean.



HISTOGRAM TABLE

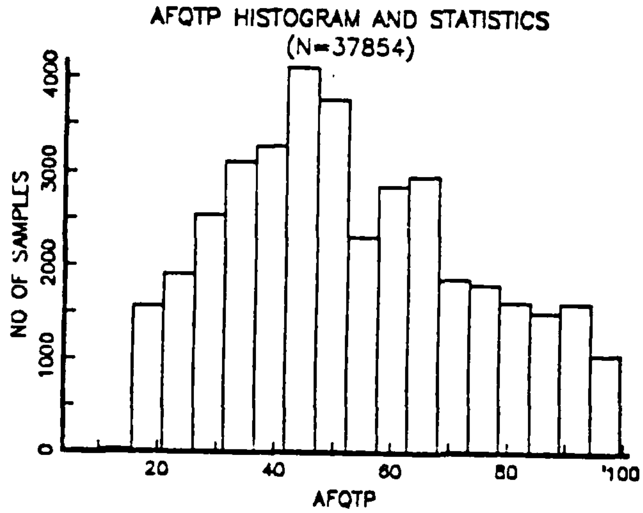
X	:GTSCR
SELECTION	:ALL
X LABEL	:GTSCR
NO OF ELEMENTS	:37854
X MEAN	:108.23
STD. DEVIATION	:14.275
SKEWNESS	:0.129
KURTOSIS	:3.3632
5-PERCENTILE	:84
25-PERCENTILE	:99
MEDIAN	:109
75-PERCENTILE	:117
95-PERCENTILE	:130
X MIN.	:54
X MAX.	:156

Figure 4.5

i. AFQTP

The Armed Forces Qualification Test Percentile is a continuous variable with ordinal scale. Its value represents the relative standing of an individual's test score referenced against a 1944 population. This means that an individual's raw AFQT score is compared against a standard table of values that was developed in 1944. This table of values from 1944 was designed to represent the distribution of raw AFQT test scores for the entire 1944 American youth population. Hence, a resulting individual AFQT score is simply the corresponding percentile of the individual raw AFQAT score relative to the entire 1944 population AFQT test distribution.

The histogram and summary statistics for AFQTP are shown in Figure 4.6. The density of AFQTP is partially symmetric about the mean. The lower five percent quartile is at a value of 21, demonstrating the restriction applied to CAT V and VI personnel since 1980. Use of the AFQT score for this study is primarily for comparative reasons. AFQT cannot be used in any developed model since scoring against the 1944 reference population has ceased. As will be seen in subsequent chapters, AFQT was discarded anyway when OAFQT proves to a better explanatory variable.



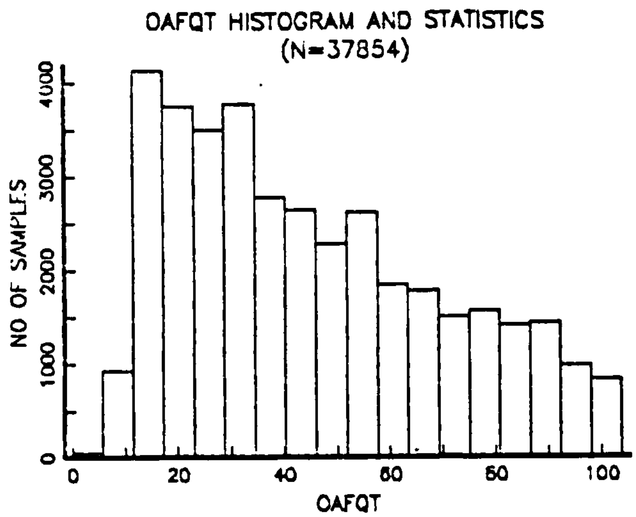
HISTOGRAM TABLE

X	:AFQTP
SELECTION	:ALL
X LABEL	:AFQTP
NO. OF ELEMENTS	:37854
X MEAN	:53.419
STD. DEVIATION	:20.965
SKEWNESS	:0.29913
KURTOSIS	:2.2128
5-PERCENTILE	:21
25-PERCENTILE	:37
MEDIAN	:50
75-PERCENTILE	:68
95-PERCENTILE	:91
X MIN.	:10
X MAX.	:99

Figure 4.6

j. OAFQTP

The OAFQTP variable is a continuous variable with ordinal scale. It is fundamentally the same as the AFQTP variable, excepting the reference for measurement, which is a 1980 population. The distribution for OAFQTP is considerably more dense in the lower values than AFQTP. Explanation of this shift can be seen by reviewing the transformation tables in Appendix A for converting 1944-based scores to 1980 scores. The transformations for values below 80 result in a 1944 based score to be reduced in almost every case. The amount of reduction varies, but it can be as much as four points. Only when the scores go above 85 are there any increasing transformations.



HISTOGRAM TABLE

X	:OAFQTP
SELECTION	:ALL
X LABEL	:OAFQT
NO. OF ELEMENTS	:37854
X MEAN	:45.319
STD. DEVIATION	:24.779
SKEWNESS	:0.53139
KURTOSIS	:2.1725
5-PERCENTILE	:14
25-PERCENTILE	:25
MEDIAN	:41
75-PERCENTILE	:64
95-PERCENTILE	:92
X MIN.	:1
X MAX.	:99

Figure 4.7

k. EIMCAT

EIMCAT is the mental category of an individual based on the 1980 reference population AFQT test score. EIMCAT is a discrete and ordinal scale variable. The assignment of categories is a Department of Defense standard, and is a common reference for all services. The breakdown of values is as follows:

TABLE VI Sample Mental Category Percentages

Value	Category	AFQT	Percent	Cumulative Percent
1	Cat V	01-09	.33	.33
2	Cat IV C	10-15	6.736	7.067
3	Cat IV B	16-20	9.788	16.854
4	Cat IV A	21-30	19.187	36.041
5	Cat III B	31-49	26.116	62.157
6	Cat III A	50-64	13.053	75.21
7	Cat II	65-92	19.99	95.2
8	Cat I	93-99	4.8	100.000

A histogram of the EIMCAT values follows in Figure 4.8.

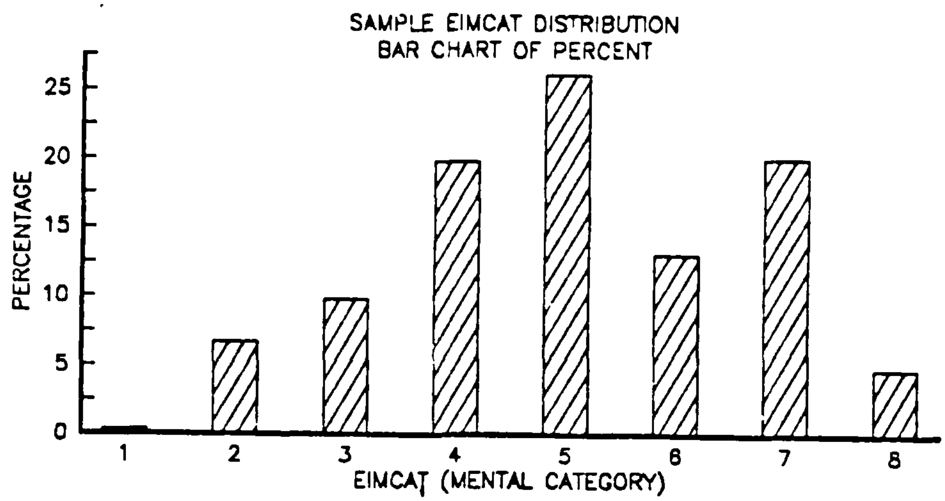


Figure 4.8

Observation of the above figures demonstrates more clearly the fact that categorization into EIMCAT category is not evenly distributed across the scale of OAFQT scores. For example, the center EIMCAT, value five, spans almost twenty points, while EIMCAT eight contains only the upper seven point scores. EIMCAT does make available an established, discrete scale measurement representing intelligence test scores for use in appropriate statistical procedures.

1. HIYRED

HIYRED is the highest year of education held by the individual upon entry into the army. It is a discrete and ordinal scale variable. The values and distribution percentages are shown on the next page in Table VII.

TABLE VII Sample Highest Year of Education			
Value	Category	Percent	Cumulative Percent
1	1-7 Years	0.018	0.018
2	8 Years	0.153	0.172
3	1 Year High School	1.397	1.569
4	2 Years High School	4.7	6.269
5	3-4 years HS (no diploma)	6.935	13.203
5.5	High School GED	4.813	18.017
6	High School Diploma	71.274	89.29
7	1 Year College	3.305	92.595
8	2 Years College	3.453	96.048
9	3-4 Years College (no degree)	1.337	97.385
10	College Graduate	2.560	99.945
11	Masters or Equivalent	0.05	99.995
12	Doctrate or Equivalent	0.005	100.000

m. EDLVL

EDLVL is the present level of education for the individual. These scores are related to HIYRED, in that any education taken by the individual subsequent to enlistment is recorded in this variable. A GED equivalency is included as a value of six for high school completion.

TABLE VIII Sample Education Level Percentages			
Value	Category	Percent	Cumulative Percent
1	1-7 Years	0.042	0.042
2	8 Years	0.011	0.053
3	1 Year High School	0.198	0.251
4	2 Years High School	0.793	1.043
5	3-4 years HS (no diploma)	1.503	2.547
6	High School Diploma	80.443	82.99
7	1 Year College	6.089	89.079
8	2 Years College	5.828	94.907
9	3-4 Years College (no degree)	2.037	96.944
10	College Graduate	2.948	99.829
11	Masters or Equivalent	0.1	99.992
12	Doctors or Equivalent	0.008	100.000

Observation of Figure 4.9, or percentages in Table VIII, shows an observable upward shift of education level after enlistment. This is possible, and encouraged with official continuing education and high school completion programs.

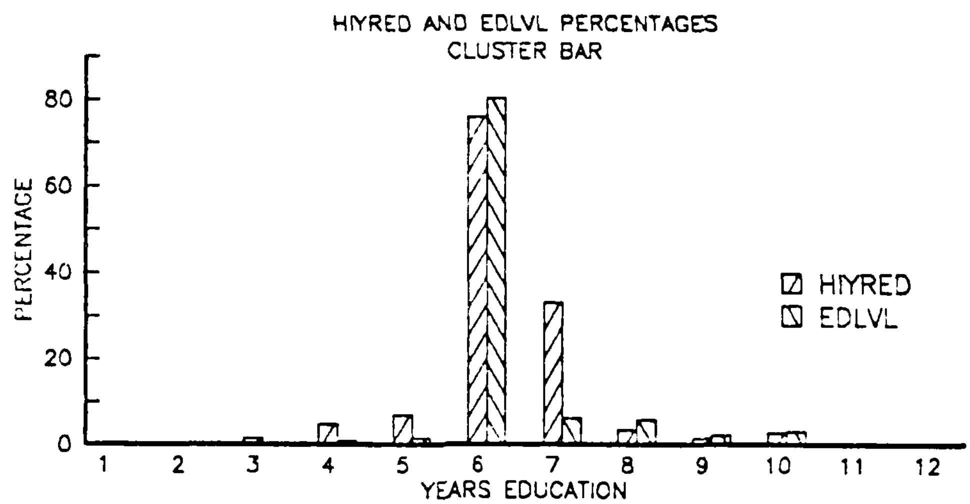


Figure 4.9

n. NCOE

The Noncommissioned Officer Education variable, NCOE, is a discrete and ordinal scale variable. It reports the level of military schooling accomplished by the individual. Military schooling categories are generally organized in three ascending levels: primary, basic and advanced. At the two lower levels, primary and basic, there are seperate courses for combat and non-combat CMF's. In some cases, there has been an award of an On-The-Job Training qualification. The OJT award is used to give credit to an NCO who can achieve technical competence in advance of being eligible for promotion to the next higher paygrade.

As previously mentioned, attendance at military schools is sometimes associated with an individual being previously identified as a superior performer. This is true mostly in the advanced level schools where selection for attendance is through Department of the Army Selection Boards. At the primary level, local commanders have authority to establish selection procedures and often will make primary school attendance a locally mandatory requirement for junior NCOs. Table IX and Figure 4.10 demonstrate the categories and distribution of NCOE.

TABLE IX Sample NCOE Percentages

Value	Category	Percent	Cumulative Percent
0	Nonparticipant	21.19	21.19
1	Primary NCO Course (CBT CMF)	4.46	25.65
2	Primary Leadership Graduate	39.36	65.25
3	On-The-Job Credit for E-5 skills	5.38	70.63
4	Primary Technical Course Graduate	2.82	73.45
5	On-The-Job Credit for E-6 skills	0.0	73.45
6	Basic Technical Course Graduate	5.11	78.56
7	Basic NCO Course (CBT CMF)	15.99	94.55
8	On-The-Job Credit for E-7 skills	.01	94.56
9	Advanced NCO Course Selectee	2.28	96.84
10	Advanced NCO Course Graduate	3.06	99.89
11	Advanced NCO nongraduate, OJT	.01	99.9
12	On-The-Job Credit for E-8 skills	.06	100.00

Figure 4.10 presents a histogram of NCOE discrete levels.

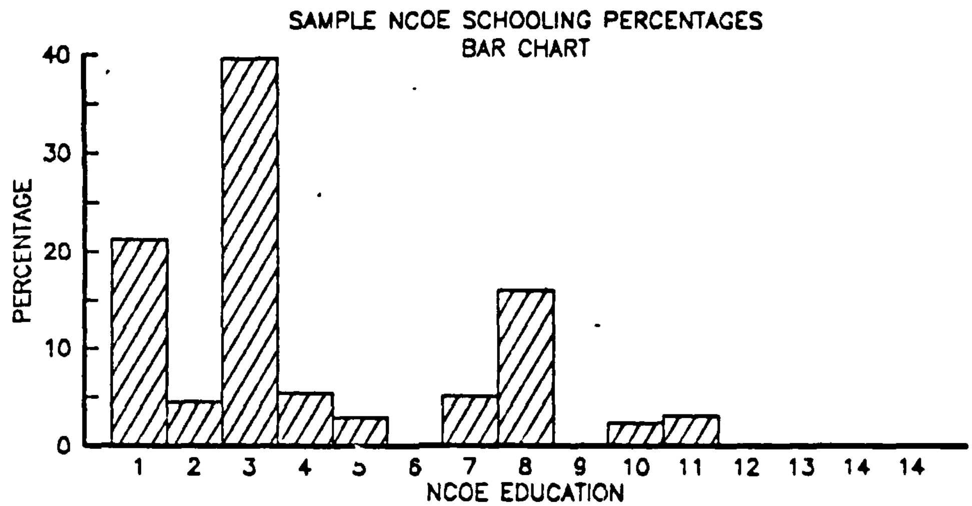
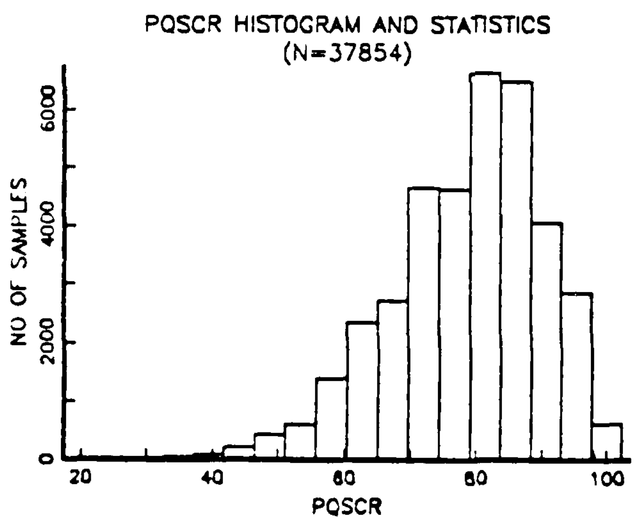


Figure 4.10

o. PQSCR

PQSCR is a report of the Primary Military Occupation Skill Qualification Test Score (SQT) of the individual. It is a continuous and ratio-valued variable. The SQT is a service related test which is used to determine the technical competence of a soldier. SQT score has been used by promotion boards as a qualitative measure for promotion. The numerical value represents the percent of correct answers on a written and hands-on evaluation. Separate SQT tests are written for each CMF, although the structure of the tests are similar.

The distribution of PQSCR, shown in Figure 4.11, is more dense in the upper values, with an abnormally long left tail extending to a lower bound of 21. An explanation for the shape of the PQSCR distribution is an involved topic, and has itself been the subject of study. A general observation is that PQSCR has previously been used in a manner where individual soldier scores were often aggregated as a means of comparison of the parent unit of the soldiers.[Ref. 11:p. 4] Thus, significant units and individual training emphasis has been focused on SQT testing in previous years, and pressure to perform well was influenced by the parent organizations. As a result, a positively skewed distribution, rather than a normal distribution, is understandable.



HISTOGRAM TABLE	
X	:PQSCR
SELECTION	:ALL
X LABEL	:PQSCR
NO. OF ELEMENTS	:37854
X MEAN	:78.384
STD. DEVIATION	:11.609
SKEWNESS	:¯0.70892
KURTOSIS	:3.5739
5-PERCENTILE	:57
25-PERCENTILE	:71
MEDIAN	:80
75-PERCENTILE	:87
95-PERCENTILE	:95
X MIN.	:21
X MAX.	:100

Figure 4.11

3. Summary

The fifteen variables used in this study demonstrate a wide variety of characteristics. All of the dependent variable choices were continuous with two, RATE and PRA, showing only slight departures from normality. The other continuous variables did not have identifiable distributions, and could not be transformed to normality using power or log transformations. Nor is it entirely clear that one would need to use a transformed variable in subsequent analysis.

The independent variables compris of a mixture of continuous and discrete values, with both ordinal and ratio scales. Within the independent variables there are two principal sets of related variables. The intelligence test scores, AFQTP, OAFQTP, EIMCAT, and to a lesser extent GTSCR, are all derived from the ASVAB. These variables differ from one another in varying degrees, and are either a re-expression, transformation, or a similarly derived set of scores.

The two academic performance measures, EDLVL and HIYRED, are related, in that EDLVL is simply the addition of additional schooling since entry into the Army.

Despite the similarities within these two sets of variables, it is felt that sufficient differences in informational value are present in each expression. Further, since the variables used are all standard data collection items for the DMDC database, each variable expression will be studied. The relative merit of any single or combined variable from this study may be useful to managers seeking appropriate data sources for other studies.

An important result of the analysis of these study variables is the observation that many of the necessary assumptions for standard parametric hypothesis testing, Analysis Of Variance (ANOVA), and possibly regression will not be met. These include assumptions about the form of the distribution as well as the scale of the variable. In this study, analysis will initially seek to use standard parametric methods. However, if results of the analysis are sensitive to distributional or scale assumptions, those assumptions will be checked. If examination of assumption requirements fails, or if there is a nonparametric test of similar efficiency, nonparametric tests will be conducted as a replacement or as a confirmatory precedure.

C. BIVARIATE ANALYSIS

This section will concentrate on identifying relationships between pairs of variables, and in identifying shifts in distribution as a function of the effects, or categorical, variables. Three methods of analysis will be used in this section. The first method is analysis of association using a matrix of Pearson product-moment correlations. This will provide intital information as to the strength of association between any two variables, and the direction of that relationship, being either positively or negatively correlated. The second method will be analysis of scatterplots of pairs of variables, using the techniques of LOWESS and Jittering to better view any trends in the variables. This method will give initial information on what type of fitted line, and hence what mathematical relationship exists between independent and dependent variables. Of significant interest will be whether the relationship is fundamentally linear, or whether it is possibly polynomial or curvilinear. The third and final method used will be analysis of three-dimensional empirical distribution plots. This will demonstrate some shifts in distribution within several of the effects variables.

1. Correlation Matrix

As earlier mentioned, the purpose of reviewing the Pearson product-moment correlation matrix is to identify pairs of variables which have a strong association. The range of the correlation coefficient, rho, is from -1 to +1, and a value of zero indicates that the variables have no linear association with each other. A value of +1 indicates an exact direct linear relationship, while a -1 indicates an exact inverse linear relationship. This measurement of association is not completely indicative of dependency, and is only a preliminary tool to identify candidate variables for testing and subsequent inferential statistics.

Remembering the central question of this thesis, the most important pairs of variables will then be any of the intelligence and academic scores paired with the promotion rate variables. Of almost equal interest will be any interval scale effects variables demonstrating a strong linear relationship with the promotion variables.

The strength of the linear relationship between two variables, or its level of significance, is based on how much variance there is in the estimated value of rho. Further, the variance of rho is dependent on the sample size being considered. For example, if the sample size were small, and the value of rho had a standard deviation of plus or minus .3, then a large positive or negative value of rho would be needed to effectively demonstrate significance. Conversly, for a large sample set with very small standard deviation for rho, a much smaller rho value could be considered significant. An estimate for the standard deviation of rho can be found by computing the inverse of the square root of the sample size. Considering the thesis sample size of 37,854, the resulting estimate of the standard deviation of rho is .005139. Thus, a value of rho different from zero by plus or minus .01, could be considered significant.

In Table X the complete Pearson product-moment correlation matrix for the study variables is given. The Pearson product-moment computation is a parametric method and assumes pairs of normal and continuous variables. This is the preferred method since we are primarily interested in correlations with either the RATE or PRA variable as one of the pair of variables. Additionally, it is possible, using the Spearman nonparametric method, to compute a correlation value rho for pairs of ordinal, or higher scale variables.

[Ref. 13:pp. 251-253] The Spearman method is a distribution free method providing correlations based on the ranks of the variables. The last column on the second part of Table X lists the correlations computed using the Spearman method. Comparison of Spearman versus Pearson values showed that there was an acceptable correspondence between the two methods, and Pearson values are used exclusively to simplify analysis.

Even with application of both the Spearman and Pearson methods there remained several pairs of variables which did not meet the assumed distributional characteristics for correct interpretation of the rho value. These variables are the discrete, nominal variables SEX, RACETH, and possibly CMF. Their results are included in Table X, but any interpretation of the rho value would be ineffective. The most important rho values in Table X are located under the PRA column and are underlined.

TABLE X Pearson Correlation Coefficients

	PRATE	RATE	PRA	GTSCR	AFQTP	OAFQTP	EIMCAT	PQSCR
PRATE	1.000	.822	.790	.035	.100	.177	.174	.039
RATE	.822	1.000	.951	.118	.155	.209	.200	.101
PRA	.790	.951	1.000	.107	.133	.177	.170	.094
GTSCR	.035	.118	.107	1.000	.741	.734	.689	.274
AFQTP	.100	.155	.133	.741	1.000	.937	.903	.308
OAFQTP	.177	.209	.177	.734	.937	1.000	.955	.315
EIMCAT	.174	.200	.170	.689	.903	.955	1.000	.305
HIYRED	.156	.168	.177	.210	.215	.245	.209	.066
EDLVL	.085	.139	.162	.266	.257	.266	.241	.100
NCOE	-.200	.047	.006	.039	-.009	-.060	-.062	.093
SEX	.013	-.019	.036	.055	.159	.050	.062	-.013
CMF	-.074	-.143	.000	.113	.106	.074	.067	-.042
RACETH	-.064	-.084	-.057	-.242	-.305	-.325	-.314	-.128
PAYGD	-.495	.000	.000	.143	.087	.031	.023	.097
PQSCR	.039	.101	.094	.274	.398	.315	.305	1.000

PEARSON COEFFICIENTS CONTINUED SPEARMAN

	PAYGD	HIYRED	EDLVL	NCOE	SEX	CMF	RACETH	PRATE
PRATE	-.495	.157	.085	-.200	.013	-.075	-.064	1.000
RATE	-.000	.168	.139	.047	-.018	-.142	-.084	.808
PRA	.000	.178	.162	.005	.036	.000	-.056	.777
GTSCR	.143	.210	.265	.039	.054	.113	-.242	.020
AFQTP	.087	.215	.258	-.009	.159	.107	-.306	.075
OAFQTP	.031	.245	.266	-.060	.049	.074	-.325	.165
EIMCAT	.023	.209	.242	-.062	.063	.068	-.313	.158
HIYRED	.001	1.000	.708	-.063	.131	.146	.024	.147
EDLVL	.098	.708	1.000	.004	.114	.177	.039	.038
NCOE	.433	-.063	.004	1.000	-.081	-.184	.015	-.208
SEX	-.057	.131	.114	-.081	1.000	.258	.042	.020
CMF	-.053	.146	.177	-.184	.258	1.000	.025	-.069
RACETH	-.016	.024	.039	.015	.042	.025	1.000	-.092
PAYGD	1.000	.000	.098	.432	-.056	-.054	-.016	-.535
PQSCR	.097	.066	.100	.093	-.013	-.042	-.128	

The most significant observations from the tables are summarized as follows:

For the variable RATE there is zero correlation with the PAYGD variable. Thus, the transformation of PRATE to RATE did remove the influence of paygrade on promotion rate. Similarly, for the variable PRA, both PAYGD and CMF have zero correlation.

As expected, the three promotion rate variables are all highly correlated in a positive direction.

With two exceptions, the correlation values for the effects and independent variables have similar magnitudes and signs across all three expressions of promotion rate. The first exception is the NCOE variable. Under PRATE it is negatively correlated with a value of 0.2, and positively correlated with lower values for RATE and PRA. This result makes sense when one considers that NCOE is highly correlated with PAYGD, (0.565). Specifically, raw promotion rates are lower for higher grade NCO's due to time in service and time in grade requirements, (-.495). Hence, NCOE, which is highly correlated with PAYGD, will also reflect that inverse relationship. When the influence of paygrade is eliminated, as it is in RATE and PRA, this negative correlation is incidentally removed.

The second exception is for the variable SEX where it is positive signed for PRATE and PRA, but negatively signed for RATE. The magnitude for all three values are close to zero.

An explanation for the difference in sign between PRA and RATE will be presented in the analysis of empirical distributions and coded scatterplots.

Groups of closely related variables have generally the same correlation across the three promotion variables. Specifically, AFQTP, OAFQTP, EIMCAT, and to a lesser extent, GTSCR, all demonstrate a strong positive correlation against each other, and show the same trend when compared against the promotion rate variables. The academic variables HIYRED and EDLVL demonstrate similar characteristics, however, EDLVL is weaker than HIYRED with respect to the promotion rate variables.

Considering RATE and PRA as the better promotion variables to model with, and allowing for only one variable from each of the related groups, the six most significant correlated variables were selected. These variables, listed in descending absolute value of rho, are shown in Table XI.

TABLE XI Most Significant Correlated Variables Considering both RATE and PRA

Variable	Rho Value
HIYRED	approx 0.17
OAFQTP	approx 0.14
GTSCR	approx 0.10
PQSCR	approx 0.09
RACETH	approx -0.06
NCOE	approx 0.006

These variables, paired either with RATE or PRA, were used as the starting basis for multivariate regression analysis. The effects variable SEX was included for subcategory analysis in an effort to detect any influence it might have on the primary relationships.

2. Paired Scatter Plots and Simple Regression

Plots of paired independent and dependent variables were implemented to accomplish two purposes. The first purpose was to visually search for any dominant plotting patterns. Since the rho values found in the previous section are designed to detect only linearity, it is quite possible that nonlinear relationships could exist between the explanatory and dependant variables. For example, if the X-Y relationship was strictly $Y=X^2$, a computed rho value should be zero. Thus, if one relied only on correlation coefficients to detect relationships, he would be misled into thinking that no relationship existed between the two variables. Simply plotting X-Y scatterplots of the explanatory variables with the promotion variables did not require specification of the response of the dependant variable. Visual observation could then be relied upon to detect dominant patterns of any form. These scatterplots used two special procedures, LOWESS and Jittering, which will be described in analysis of Figures 4.12 and 4.13.

Secondly, simple least squares regression was performed for all variables which had been previously found to be significantly correlated. The simple least squares regression procedure yielded a value called the Coefficient of Determination, or R2 (R-square). R2 is mathematically related to the rho, and in the one variable case, the square of rho is equal to R2. Thus, R2 can also be used to qualitatively interpret the strength of linearity for a simple linear model. The advantage of producing R2 values was that R2 directly represents the proportion of variance accounted for by the assumption of a linear model. The results for each of the regressions and an explanation of R2 will be discussed in analysis of Table XII.

a. Paired Scatterplots

Since interpretation of the correlation coefficients assumes linearity, visual analysis of pairwise scatterplots was used to search for observable patterns, linear or otherwise. This visual approach did not require interpretation of single derived parameters to identify any patterns.

In producing the scatterplots the LOWESS procedure was used. LOWESS, which stands for, Locally Weighted Regression Scatter Plot Smoothing, [Ref. 12:pp 94-95] is a nonparametric smoothing procedure which is designed to estimate functional relationships between Y and X. In particular, no linear or quadratic relationship is assumed. For scatterplots of discrete variables against the continuous promotion rate variables, the discrete variables were Jittered to overcome repeated plotting of points. Jittering involves generating small random increments, which are then added to the X values. As a result, when the X-Y plot is performed fewer X values are repeatedly plotted in the same location, and a better visual interpretation can be made of the quantity of X values at a discrete level.

The overall results of the LOWESS plots showed that the predominant pattern was indeed linear. Further, the linear pattern was demonstrated most clearly between pairs of highly correlated variables. Figures 4.12 and 4.13 demonstrate that linearity and the LOWESS and Jittering techniques respectively. As a result, linear modelling techniques were considered to be the best choice for subsequent analysis.

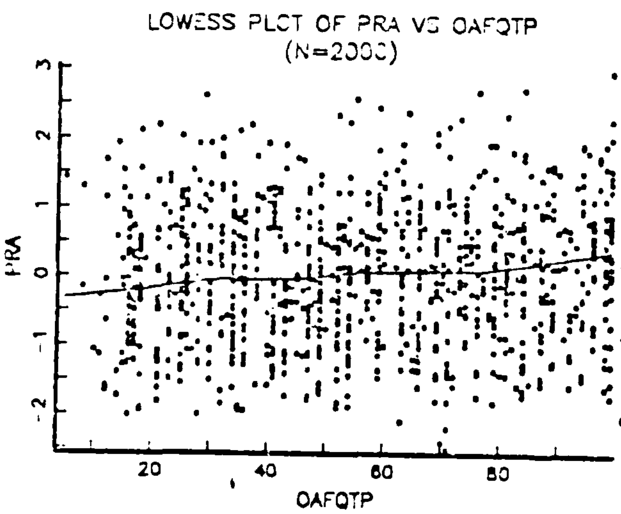


Figure 4.12

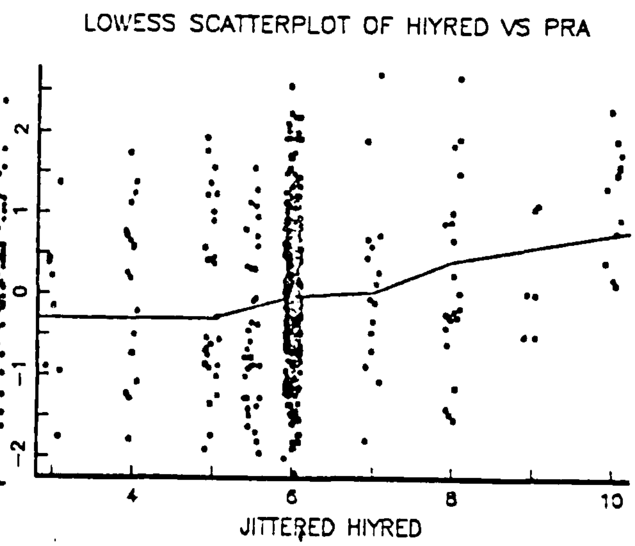


Figure 4.13

b. Simple Regression

For pairs of significantly correlated variables, a simple least squares regression plot using PRA as the independent variable was accomplished. The simple least squares regression for pairs yields quantitative results in terms of slope values, intercept values, tests of the slope and intercept values, and the R2 value.

The R2 value represents what proportion of total variance was explained by the simple linear model. As such, its values range from zero to one. An R2 value of zero would indicate that a linear model does not account for any variance of the dependent values. Correspondingly, a value of zero would be the estimate of the slope of the line. The significance of R2, like rho, is related to sample size. To determine the significance of a R2 value, the results of the T test for the slope of the model are checked. If the T statistic is large and the probability of a greater T value small, a null hypothesis of a slope of zero is strongly rejected. Thus, we can be confident of the linearity of the model and the derived slope estimate. Sample size is considered in this test because the T statistic is computed as a function of sample size. Thus, even with a small R2 value, if the T test for the slope were significant, the R2 value would necessarily be held as significant. The only qualification for a low R2 value would be that there exists considerable 'noise' or unaccounted variance in the response of the dependent variable. A summary of results are shown in Table XII.

TABLE XII Simple Least Squares Summary Data using PRA as Dependent Variable

Variable	Intercept	Std Err	Slope	Std Err	R2	T
GTSCR	-0.856	(0.0061)	0.008	(5.6E-04)	.013*	[illegible]
AFQTP	-0.338	(0.014)	0.006	(0.0002)	.018*	26.1
OAFQTP	-0.336	(1.6E-02)	0.007	(3.2E-04)	.033*	[illegible]
EIMCAT	0.004	(0.027)	0.003	(0.005)	.000	[illegible]
HIYRED	-0.005	(0.047)	-0.001	(0.008)	.000	[illegible]
EDLVL	0.011	(0.054)	0.003	(0.008)	.000	[illegible]
NCOE	-0.020	(0.021)	0.003	(0.003)	.000	[illegible]
SEX	0.011	(0.028)	0.018	(0.024)	[illegible]	[illegible]
CMF	0.023	(1.6E-02)	0.000	(2.6E-04)	.000	[illegible]
RACETH	-0.009	(0.018)	0.001	(0.010)	.000	[illegible]
PAYGD	0.045	(0.093)	[illegible]	(0.018)	.000	[illegible]
PQSCR	0.059	(5.4E-02)	0.007	(6.9E-04)	[illegible]	[illegible]

Important observations from the simple paired regression analysis are summarized in the following paragraphs.

Very few sets of pairs result in a significant R [illegible]. Those that do are: GTSCR, AFQTP and PQSCR. [illegible] these variables have a positive slope. [illegible] for these pairs did not show [illegible] and did not demonstrate any [illegible].

The remaining variables have [illegible] negative slope. [illegible] confidence interval [illegible] value of the slope [illegible] observable [illegible]

[illegible]

AFQTP having measurable R2 values and positive slopes.

As expected, the results of the simple regression analysis coincide with observations taken from the correlation table.

When considered one at a time, there appear to be only a handful of variables demonstrating a reportable relationship with the promotion variables. The low R2 value for each regression indicates either a large proportion of pure error, or significant unexplained variance due to other explanatory variables not being included.

3. 3-D Empirical Density Plots

Three dimensional empirical density plots were used to visually check for distribution changes in the continuous variables within the subcategories of SEX, PAYGD and RACETH. Two such plots will be discussed because they depict visually data characteristics identified in earlier tabular results. These characteristics were: the application of AFQT restrictions by congressional mandate in 1980, and the differences in OAFQT scores across racial groups.

The AFQT restriction is depicted in Figure 4.14, where empirical densities for OAFQT are plotted for each paygrade. Observing the three densities shows that only the E-7 paygrade distribution contains scores less than twenty. This makes sense, considering that all the E-7 enlistments were prior to 1980. Another interesting observation from this plot is that high OAFQT scores become more dominant as paygrade increases. This is most apparent in comparing the E-7 density to either the E-5 or E-6. This shift in density of OAFQT across the three paygrades suggests that attrition tends to manifest itself in the lower AFQT caetgories, but that a low AFQT score is, in itself, not prohibitive in achieving senior enlisted rank.

The second 3-D empirical density plot, Figure 4.15, shows the differences in renormed AFQT scores across racial subcategories. A large discrepancy between the white and the distribution of black or hispanic races is easily seen, although Indians have a similar AFQT to that of whites. This observation coincides with the occurrence of different promotion rates between different racial categories as well. However, to make inferences about promotion policy among races would require further research. As pointed out by Daula, [Ref. 11:pp. 7-10] the attrition pattern among different racial groups shifts the averages for both promotion rate and AFQT among the races over time. Since the purpose of this thesis is one of prediction, it is more important to identify the effect and account for it in the model. An explanation as to the cause of this phenomenon does not appear to be easily obtained from the thesis data.

What is important about this plot is that it visually demonstrates the correlation between RACETH and OAFQT. If OAFQT is a significant determiner of promotion rate, then RACETH will be an important covariate.

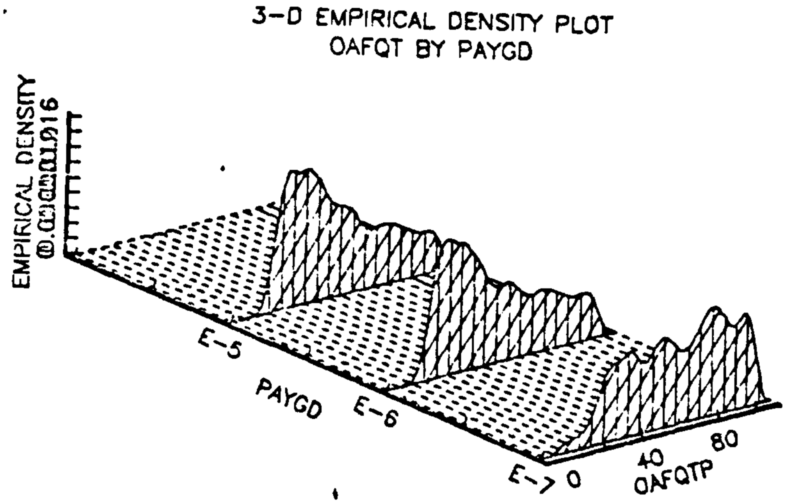


Figure 4.14

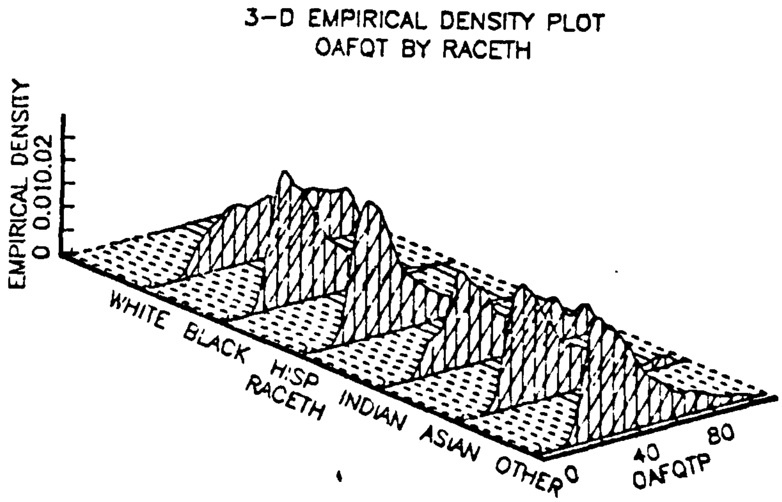


Figure 4.15

D. MULTIVARIATE GRAPHICAL ANALYSIS

Multivariate graphical analysis consisted of the use of Draftsman Plots and Coded Scatter Plots to look for relationships when more than two dimensions were under consideration. [Ref. 12:pp. 135-139] One of these procedures, the Coded Scatterplot, will be utilized to demonstrate a significant data characteristic, that characteristic being the distribution of SEX, correspondent to CMF and PRA, in Figure 4.16.

Coded Scatterplots involved delineating one of the effects variables as a third dimension, while plotting an independent variable against a dependent promotion variable. In Figure 4.16, CMF values were Jittered and plotted against the PRA variable, and the plot points were coded as periods for males and the letter F for females.

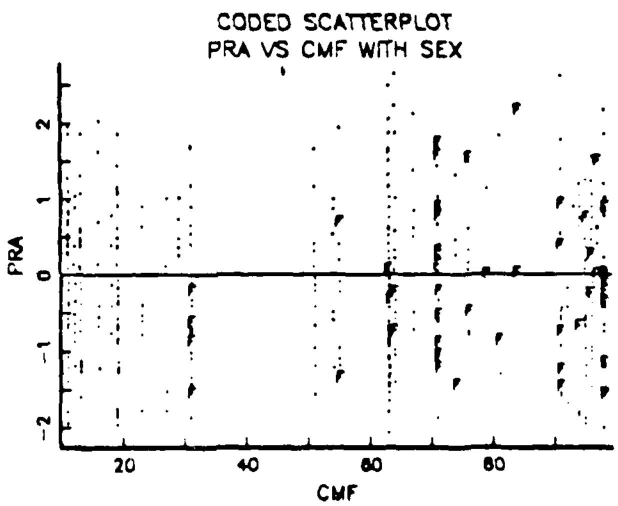


Figure 4.16

Figure 4.16 demonstrates the higher density of female personnel in the upper CMF range, which contains the more technically oriented career management fields. This corresponds to the CMF-SEX correlation coefficient [illegible] found in Table X. Likewise, the distribution of both the female and male PRA scores are symmetric about the zero line.

This corresponds to the zero value for the PRA-SEX correlation coefficient also found in Table X.

E. LINEAR MODELS

1. Analysis of Variance

One Way ANOVA was used in this thesis as an intermediate step in defining a final inference model. ANOVA's usefulness has been as an investigative tool to detect differences in means among classes of explanatory variables. For example, using PRA as the dependent variable and EIMCAT as the independent variable, One-Way ANOVA will compare and test the equality of the average PRA score across the eight levels of EIMCAT, i.e., mental categories one through eight. In the testing, the null hypothesis is that all eight mental category PRA means are equal, while the alternate hypothesis is that they are not. The test statistic used to reject or accept the null hypothesis is the F statistic. As such, a large F value, and subsequent rejection of the null hypothesis would indicate that there exists significant differences between the means of the promotion scores for some of the eight mental categories. In general, a large F value can be considered to be any computed F statistic greater than 3.84, the asymptotic 95 percent point for a one degree of freedom model. The nature of these differences could be a large discrepancy between a simple pair of categories, small discrepancies between all eight categories, or any combination of difference conditions. Thus, ANOVA has limited value in discerning the location and magnitude of the differences between category means, but it does identify if differences exist and how strong those differences are.

Table XIII tabulates a twelve by three matrix of results for separate One-Way ANOVA's. The rows are the twelve explanatory variables and the columns are the three promotion variables. Using all three promotion measures as the independent variable allowed for a check of ANOVA values and trends across those measures.

In addition to the results of the F test, a value of R2 is reported. This R2 value is different than that reported in the simple linear regression model. This is because the ANOVA procedure considers the independent variable as a set of levels, rather than a single continuous variable. With One Way ANOVA, all variables had some level of R2 reported. Further, because of the increased informational value of variable categories, and hence, more degrees of freedom for computation, the values of R2 increased above the simple regression reported values.

It should be noted that technically, when the defined continuous variables were put into ANOVA, their values were grouped, and then the variables were treated as if they were discrete. Because the SAS software and computational resources used could handle all the integer values for the score ranges of AFQTP and the other continuous variables, it was possible to gain insight into the existence of differences between individual score cells.

Additionally, nonparametric procedures were used to evaluate the relationships. [Ref. 13:pp. 250-255] The nonparametric ANOVAs utilized the ranks of the variables and also yielded the F statistic for testing the hypothesis of equal level means. Having agreement between the parametric and nonparametric values removed the need of having to pursue confirmation of assumptions for parametric ANOVA. It will also allow analysis of results to focus on the resultant values of F and R2 tabulated in Table XIII.

TABLE XIII One-Way Anova Summary

Variable	PRATE		RATE		PRA	
	F	R2	F	R2	F	R2
SEX[1]	5.9	.00016	13.3	.00351	48.4	.00128
CMF[2]	35.	.02788	93.3	.07415	0.0	.00000
RACETH	90.	.01177	165.0	.02133	80.0	.01049
PAYGD[3]	6292.	.24953	0.0	.00000	0.0	.00000
GTSCR	18.	.04250	13.4	.03184	10.9	.02636
AFQTP	32.	.07046	20.6	.04623	17.3	.03908
OAFQTP	36.	.08441	25.3	.06101	19.	.04657
EIMCAT	37.	.01076	71.5	.02035	96.9	.02739
HIYRED	96.	.02950	106.0	.03272	117.	.03590
EDLVL	37.	.01076	71.5	.02035	96.9	.02739
NCOE	156.	.05097	76.4	.02499	46.8	.01583
PQSCR	1.9	.00375	6.6	.01341	5.8	.01181

[1] The Pr>F (level of rejection of the null hypothesis of no difference in means) was .0145 for PRATE, .0003 for RATE and .0001 for PRA.

[2] The Pr>F for PRA is 1.0.

[3] The Pr>F for RATE is 1.0, and for PRA is 1.0. Values of Pr>F for the remainder of the table were .0001.

Review of the Table XIII demonstrates some anticipated results, which are summarized in the following paragraphs.

Since the variables PAYGD and CMF were controlled for in the derivation of PRA, there is correspondingly no relationship between those variables and the PRA promotion variable. Likewise, the variable PAYGD was controlled for in the derivation of RATE, and there was no linear relationship demonstrated for that pair. The zero values for the F statistic and R2 for those variable combinations documents this fact.

Using RATE or PRA as the dependent variable, and allowing for only one, most significant variable to be selected from each of the intelligence and academic groups, results in the same set of explanatory variables as were found in correlation analysis. These variables were: HIYRED, OAFQTP, GTSCR, PQSCR, RACETH, NCOE, and SEX. The most significant variables were the ones which had the larger F statistic, and R2 value. This set is not ordered, however, since there are differences in order between the PRA and RATE models.

Another interesting development from ANOVA results when the explanatory variable mean and variance for each level are plotted against the promotion variable. This not a standard analytical plot, but it does provide some visual information on the size, direction, and dispersion about the center line of an independent discrete variable. This plot is most similar to a strip box plot for continuous variables.

An example plot where each individual's PRA score was plotted against the sum of his EIMCAT and HIYRED score is shown in Figure 4.17. In Figure 4.17 the two center lines plotted represent the sum of scores for EIMCAT and HIYRED seperated between the GED qualified personnel and High School Diploma Qualified personnel. The outside two lines trace the upper and lower bounds one standard deviation from the computed means.

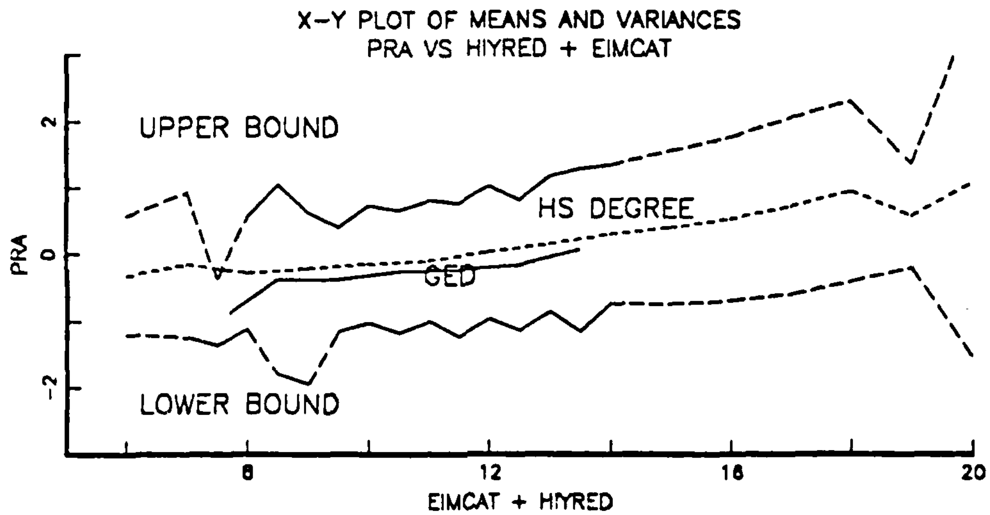


Figure 4.17

By plotting a separate line for each high school diploma category it can be seen that while both groups have a similar increase in promotion rate, as the combined level of EIMCAT and HIYRED increased, the GED qualified personnel were consistently a fixed level lower than a fully qualified high school graduate. Thus, the additional merit of an actual high school diploma did manifest itself in promotion rate.

A final look at ANOVA involves specifying a model using the set of the seven most significant independent variables, and then checking for interactions among them. Table XIV gives the results of the Seven-Way ANOVA using this model:

RATE = 7 Main Effects + Two Way Interactions

Table XIV depicts the seven most significant variables individually in the Main Effects rows, and the interaction terms in the Interactions rows.

The advantage of this Seven-Way ANOVA is that inclusion of all of the explanatory variables simultaneously allows for comparison of the significance of each of the explanatory variables relative to the others. Additionally, specifying combinations of two-way interactions checks to see if any two of the explanatory variables are significantly related to one another. An example of an interaction would be a SEX and CMF term. As has been previously shown, female personnel tend to be associated with higher CMF values. If the ANOVA model for promotion included a term which was the product of the two values, SEX*CMF, then the two attributes would be jointly considered in the ANOVA model. If the interaction term was found to be significant, then the two individual variables entries for CMF and SEX would be removed and only the interaction term retained.

An additional consideration in the Seven Way ANOVA was that the model was unbalanced. Unbalanced means that there were some combinations of the factor levels which did not have any entries in the ANOVA cells. An example of this can be seen in the SEX*OAFQT term. Specifically, there are only 76 degrees of freedom for the interaction term, while the individual degrees of freedom for SEX and OAFQT are 1 and 79 respectively. Thus, the SEX*OAFQT term had three combinations without entries. As a result, the F statistic computed will be only approximate. Since the purpose of this step in analysis was exploratory, the F statistic estimates were considered adequate.

Table XIV presents the results of a Seven Way ANOVA using RATE as the dependant variable. Similar results were obtained using PRA as the dependant variable.

TABLE XIV 7-Way Analysis of Variance with Interaction

DEPENDENT VARIABLE: RATE

SOURCE	DF	SSQ	MEAN SQUARE	F VALUE	PR > F	R2
MODEL	14966	18869.39	1.260818	1.52	0.0001	0.49852
ERROR	22887	18981.65	0.829364			
CORRECTED TOTAL	37853	37851.04		ROOT MSE 0.91069421		

SOURCE	DF	ANOVA SS	F VALUE	PR > F	
Main Effects					
RACETH	5	807.35	194.69	0.0001	
SEX	1	13.28	16.02	0.0001	
OAFQT	79	1670.54	25.50	0.0001	
HIYRED	12	1238.25	124.42	0.0001	
GTSCR	93	1205.22	15.63	0.0001	
NCOE	13	945.89	87.73	0.0001	
PQSCR	78	507.52	7.85	0.0001	
Interactions					
RACETH*SEX	5	0.00	0.00	1.0000	
SEX*OAFQT	76	440.59	6.99	0.0001	*
SEX*HIYRED	9	66.03	8.85	0.0001	*
SEX*GTSCR	72	72.80	1.22	0.0999	
SEX*NCOE	11	57.76	6.33	0.0001	*
SEX*PQSCR	70	53.06	0.91	0.6795	
RACETH*OAFQT	335	0.00	0.00	1.0000	
RACETH*HIYRED	46	107.84	2.83	0.0001	*
RACETH*GTSCR	326	0.00	0.00	1.0000	
RACETH*NCOE	46	8.41	0.22	1.0000	
RACETH*PQSCR	288	104.24	0.44	1.0000	
OAFQT*HIYRED	593	112.62	0.23	1.0000	
OAFQT*GTSCR	2864	2418.55	1.02	0.2570	
OAFQT*NCOE	614	954.24	1.87	0.0001	*
OAFQT*PQSCR	3631	3182.33	1.06	0.0137	
HIYRED*GTSCR	564	130.88	0.28	1.0000	
HIYRED*NCOE	88	276.98	3.80	0.0001	*
HIYRED*PQSCR	518	484.13	1.13	0.0251	
GTSCR*NCOE	604	718.86	1.44	0.0001	*
GTSCR*PQSCR	3383	2997.93	1.07	0.0051	
NCOE*PQSCR	542	504.44	1.12	0.0268	

Three important observations can be obtained from Table XIV. The first observation is that there are few significant interaction terms. Only those terms marked with an asterisk demonstrated statistical significance with the ... level .0001. Of these, only three had F values greater than 3.8. These interaction terms were OAFQTP, HIYRED, and NCOE, all interacting with SEX. The presence of interaction terms in the Seven-Way ANOVA model was previously observed in the correlation matrix, Table X, where SEX was positively correlated with HIYRED and OAFQTP, (0.0..., and ..., respectively), and negatively correlated with NCOE, ... The implication of having significant interaction terms is that they would need to be included in any predictive model. Thus, identification of interactions using ANOVA was critical.

Secondly, all the main effects variables continue to be significant, even when used simultaneously by the model.

Lastly, selecting the single most significant explanatory variable from the academic and education groups yields the same unordered best set as did the One-Way ANOVA: OAFQTP, HIYRED, GTSCR, NCOE, RACETH, and SEX.

In summary, the fundamental result of ANOVA was the confirmation that there are differences in the level means of promotion scores due to several independent explanatory variables, and ar agreement as to which were the best explanatory variables when considered separately or simultaneously.

Also, plotting the means and variances of the sum of EIMCAT and HIYRED versus PRA demonstrated that there was a [illegible] increasing [illegible]. However, there was considerable variance within each class level. The choice of [illegible] and [illegible] as the explanatory variables was important because these variables are both discrete representatives from the academic aptitude and [illegible].

ANCOVA

The use of One Way Analysis of Variance in the previous section was primarily to confirm the existence of significant differences among the levels of the independent variables. Beyond acknowledging that there are some independent variables available to explain promotion rates, One Way ANOVA did not provide any numerical measure of the structural form of the contribution of a given independent variable to the model. [Ref. 14:p. 10] In addition, in analysis of the continuous variables, the nature of the variable was changed to represent a discrete valued variable.

Incorporating continuous variables into ANOVA was achieved through the intermediate method of ANCOVA. ANCOVA utilizes metric continuous variables as well as nonmetric qualitative values. The result of ANCOVA was an improved multivariate model with the inclusion of continuous variables in their proper form. ANCOVA provided estimates of the linear coefficients for the continuous variables, and reported on the proportion of variance accounted for by each categorical variable as well. These results provided the basis for further removal of variables or interactions from the set previously identified. [Ref. 15: pp. 343-349]

The model considered was based on the results of the previous chapters and consisted of the following form:

Promotion = f(OAFQTP,PQSCR,GTSCR,HIYRED,NCOE,RACETH,SEX

plus interaction terms SEX*HIYRED, SEX*GTSCR, SEX*OAFQTP)

The variables OAFQT, PQSCR, and GTSCR are metric and continuous, HIYRED and NCOE are discrete and metric, and RACETH and SEX are discrete and nonmetric.

A representation of the model using notation consisted of the following form:

$$Y_i = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + D^1 + D_2 + \ldots D_4 + I_1 \ldots I_3$$

In the above notation, Y_i is the promotion variable PRA, B_0 is the linear intercept, and B_1 through B_3 are coefficients for the continuous variables OAFQT, GTSCR and PQSCR. The coefficients B_1 through B_3 are assumed to be the same for all levels of the other variables. D_1 through D_4 represent the discrete variables RACETH, SEX, HIYRED, and NCOE. I_1 through I_3 are the interaction terms OAFQT*SEX, HIYRED*SEX, and NCOE*SEX.

This model is also unbalanced and the F statistics are estimates. The results of the ANCOVA using this model are shown in Table XV.

TABLE XV ANCOVA with Interactions

DEPENDENT VARIABLE: PRA

SOURCE	DF	SSQ	MEAN SQUARE	F VALUE	PR > F	R2
MODEL	55	2423.68	44.07	47.13	0.0001	0.0642
ERROR	37798	35339.29	0.934		ROOT MSE	
CORR TOTAL	37853	37762.98			0.966	

SOURCE	DF	TYPE III SS	F VALUE	PR > F
<u>Main Effects</u>				
OAFQT	1	12.89440024	13.79	0.0002
RACETH	5	152.10095609	32.54	0.0001
SEX	1	5.31950192	5.69	0.0171
HIYRED	12	517.91751116	46.16	0.0001
GTSCR	1	3.65772995	3.91	0.0479
NCOE	13	132.83314221	10.93	0.0001
PQSCR	1	80.15632971	85.73	0.0001
<u>Interactions</u>				
OAFQT*SEX	1	4.03387863	4.31	0.0378
SEX*HIYRED	9	10.16825209	1.21	0.2844
SEX*NCOE	11	18.42527136	1.79	0.0496

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	0.25501	0.31	0.7592	0.83191986
OAFQT	0.00094	1.26	0.2077	0.00074544
GTSCR	-0.00104897	-1.98	0.0479	0.00053034
PQSCR	0.00422902	9.26	0.0001	0.00045674

There are three important observations from Table XV. First, the main effects variables, with the exception of GTSCR, are still significant in their ability to account for variance in the model.

Secondly, no interaction terms are significant. The PR > F for these terms are much greater than .0001 and each has a small F value. Thus, the effect of the interaction terms will be assumed to be negligable.

Lastly, the bottom portion of the ANCOVA table lists estimates of regression coefficients for the continuous variables. These estimates were tested, using the T statistic, to see if they were significantly different from a hypothesized value of zero. If the estimate was not significantly different from zero, then the explanatory variable did possess sufficient predictive ability.

The PQSCR coefficient has a small, but positive slope with a value of 0.0042, and is significantly different from zero. The OAFQT variable has a slope with the correct sign and magnitude, but it is not significantly different from zero. The GTSCR variable demonstrates a negative slope and again is not significantly different from zero.

The negative estimate value, combined with the knowledge that GTSCR is strongly correlated with OAFQT, indicated a condition of multicollinearity between the two variables. Multicollinearity implies that one variable may be simply a surrogate for the other with little or no effect as a predictor.[Ref. 15:p. 415] Thus, the inclusion of GTSCR coincident to OAFQT was considered detrimental to the development of a regression model, and it was dropped from subsequent analysis.

In summary, ANCOVA resulted in the elimination of the remaining interaction terms from consideration in the predictive model. The estimated values of OAFQT and GTSCR demonstrated a condition of multicollinearity in the model, and the weaker variable, GTSCR, was eliminated. The remaining variables to be considered in subsequent analysis were: OAFQT, PQSCR, HIYRED, NCOE, RACETH, and SEX. These results were considered satisfactory, in that the remaining variable set contains single measures of academic aptitude, education, professional education, military performance testing, as well as two categorical variables: SEX and RACETH.

3. The Final Model: A Multiple Regression (ANCOVA)

a. Background

Regression analysis with a reduced set of variables was the final step in successive data analyses. The important result of this analysis was a set of coefficient values which estimated qualitative numerical statements about the independent influence of each of the explanatory variables. Of specific importance was the independent influence of OAFQT and HIYRED in predicting an individual promotion rate.

In the development of the regression model this section will:

1. Review the pertinent results which led to the regression model definition.
2. Compare the model using the three promotion rate variables.
3. Select a single promotion variable for the model.
4. Interpret the resulting regression estimates and conduct sensitivity analysis.
5. Check model assumptions and confirm the model using an alternate data set and nonparametric procedures.
6. Test the model by comparing actual versus predicted promotion rates for population subcategories.

Previous results are reviewed in the following paragraphs.

ANOVA and ANCOVA demonstrated that significant differences exist between internal levels of the explanatory variables as a function of average promotion rates.

Paired scatterplots utilizing smoothing techniques, and plots of the level means found in ANOVA, consistently demonstrated an ascending linear pattern when plotted against promotion variables.

ANOVA and ANCOVA models, using interactions, resulted in the elimination of variables which did not demonstrate sufficient linear additive effect to be included in the model. Further, this analysis confirmed that there was no significant interaction among the remaining variables.

Correlation analysis, combined with the in-depth univariate analysis as to the nature and scoring procedures of the individual variables, identified groups of variables. In subsequent analysis, these groups were then restricted to allow for only the strongest unique variable to be entered into the model.

The final set of variables for entry into the model are the following:

Promotion = f(OAFQT,PQSCR,HIYRED,NCOE,RACETH,SEX)

This model is a mixed scale and variable type model, including both discrete and continuous variables. Two of the input variables have nominal scale, RACETH and SEX. To allow for their entry into the model, these values were transformed into dummy variables. Specifically, the variable SEX was recoded as a 0/1 variable, while RACETH was represented with five dummy 0/1 variables, D1 through D5. For example, for the RACETH score of 1, the dummy variable D1 was coded with a 1 for every 1 entry and a zero for all others. This procedure was applied for the next four levels, while score 6 was left as a 0/0 entry. (Ref. 15:pp. 332-341)

After application of the recoding just described, the regression model can be defined with the notation:

$$Y_i = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + D_1 + \ldots + D_5 + D_6$$

In the above notation, Y_i is one of the promotion variables, B_0 is the linear intercept, and B_1 and B_2 are coefficients for the continuous variables OAFQT, and PQSCR. B_3 and B_4 are coefficients for the discrete and ordinal variables HIYRED and NCOE. D_1 through D_5 represent the dummy variables for RACETH, and D_6 represents the dummy variable for SEX.

The data set of 37,854 records was randomly split into two separate data files for regression analysis. This provided for a different data set to confirm analysis of regression coefficients from the first set. Paragraph e.1. of this section compares resulting regression coefficients of the model using the second data set.

b. Results

Table XVI lists the regression results of the basic model variables. When computing models for PRATE and RATE the effects variables CMF and then CMF and PAYGD were reintroduced into the set of explanatory variables respectively. This allowed for comparison of variable coefficients and R2 value changes as the dependent variable became more restricted. In Table XVI the top paragraph shows the ANOVA results of the model and reports the F and R2 statistic. Each column then gives the regression results of each promotion rate model, including a Pr>T value as measure of the strength of rejection for a null hypothesis of zero for the estimate value. Values of Pr>T less than .05 are considered acceptable for consideration of that variable.

TABLE XVI Regression Results

	PRATE	RATE	PRA
Added Variables	CMF, PAYGD	CMF	None
ANOVA F	1317.4	360.3	218.5
Pr>F	.0001	.0001	.0001
R2	.3116	.0948	.0546
Intercept	0.022222	-1.03692	-1.28822
(std error)	(.002558)	(.055368)	(.05600)
Pr>T	.0001	.0001	.0001
OAFQT	.0001355	.0058817	.0042608
(std error)	(00000871)	(.0002444)	(.0002492)
Pr>T	.0001	.0001	.0001
HIYRED	.0005341	.148352	.139484
(std error)	(.000152)	(.004851)	(.0049298)
Pr>T	.0001	.0001	.0001
PQSCR	.000089	.001608	.00327211
(std error)	(.000014)	(.000449)	(.0004583)
Pr>T	.0001	.0001	.0001
SEX	-.0008582	.022904	.0564079
(std error)	(.00050325)	(.01562)	(.0155310)
Pr>T	.088*	.1427*	.0003
NCOE	.00008839	.012688	.0073740
(std error)	(.00000625)	(.0017808)	(.0017949)
Pr>T	.1573*	.0001	.0001
D1 (RACETH)	.0026347	.053088	.01497054
(std error)	(.0011286)	(.035653)	(.0363905)
Pr>T	.0196	.1365*	.6808*
D2 (RACETH)	- .0037888	-.096320	-0.0898693
(std error)	(.0011266)	(.035570)	(.0363089)
Pr>T	.0008	.0068	.0013
D3 (RACETH)	- .0009404	-.0239592	-.0417668
(std error)	(.001279)	(.040383)	(.04122033)
Pr>T	.4623*	.5530*	.3109*
D4 (RACETH)	.00028892	.089059	.01007473
(std error)	(.0032534)	(.102707)	(.1048355)
Pr>T	.3745*	.3859*	.9234*
D5 (RACETH)	-.000224	-.021530	-.0138649
(std error)	(.0018127)	(.0572261)	(.058409)
Pr>T	.9016*	.7067*	.8124*
CMF	-.000147	-.0053672	NA
(std error)	(.0000052)	(.0001654)	
Pr>T	.0001	.0001	
D7 (PAYGD)	.060127	NA	NA
(Std error)	(.0017904)		
Pr>T	.0001		
D8 (PAYGD)	.017999	NA	NA
(std error)	(.001774)		
Pr>T	.0001		

Observations from the regression table are summarized in the following paragraphs.

The input variables OAFQT, HIYRED, and PQSCR all maintained a positive and statistically significant coefficient value across all three dependent variables.

The inclusion of PAYGD with the PRATE variable significantly increased the R2 value of the model. Conversely, the influence of OAFQT, HIYRED, PQSCR, and the other explanatory variables was severely diminished.

The RATE model is very similar to the PRA model, and has generally larger estimate values and a higher R2. However, the estimates for RACETH and SEX did not have significant T values.

The PRA model, although having a lower R2 value and generally smaller estimate values, had an acceptable T test result for SEX. Additionally, the PRA model contained one less nominal explanatory variable, CMF. The PRA model then, has fewer, and more reliable nominal explanatory variables. Since the objective of the study was to focus on academic and educational measures as predictors of promotion, the PRA model was chosen as the most effective predictive model. Subsequent analysis of regression coefficient results were conducted with the PRA model.

c. Interpretation

Interpretation of the regression coefficients will include two points. First, the explanatory variables which can effect the greatest change in the dependent variable will be identified. Secondly, an example will demonstrate the amount of change in a given explanatory variable required to achieve a five percent shift in the PRA estimate.

The amount of change in PRA caused by a change of one unit of an explanatory variable can be read directly from the regression coefficients. However, the total amount of change that an explanatory variable can cause in PRA depends on the range of the explanatory variable. Table XVII gives an ordered listing of the explanatory variables, excluding categorical variables, from most to least total influence as measured by Net Possible Change. The net possible change is simply the number of units in the range of the explanatory variable multiplied by the coefficient estimate.

TABLE XVII Net Possible Change by Explanatory Variable

Variable	Range	Estimate	Net Possible Change
HIYRED	1-12	.13948378	1.6738
OAFQT	1-99	.00426083	0.4218
PQSCR	21-100	.00327212	0.2585
NCOE	0-14	.00737408	0.1106

In a qualitative sense, the sensitivity of PRA to each explanatory variable can be demonstrated by deriving the number of explanatory variable units needed to move from the median PRA value up five percent.

To compute the average value for PRA, the population average for each explanatory variable was entered into the regression model. The resulting PRA value was [illegible] using the normal approximation [illegible] of the PRA distribution. An upward shift of [illegible] then require the PRA value to lie at the [illegible] Using the standard normal tables [illegible] distribution, the PRA value corresponding [illegible] percentile was 0.1434. Checking the sensitivity [illegible] explanatory variable consisted of changing [illegible] explanatory variable a sufficient number of units to result in a PRA value of 0.1434, while holding all other explanatory variables at the population average. Table XVIII tabulates the increase of explanatory variable units necessary to produce a 5 percent upward shift in PRA percentile. Alternatively, if the amount required to reach the 55.7 percentile was not possible within the range of the input variable, the maximum amount of available change was listed.

TABLE XVIII Sensitivity of PRA to Explanatory Variables

Variable	Average Value	Change to	Pra % Change
HIYRED	6.01	7.0	55.9
OAFQT	45.3	74.0	55.7
NCOE	3.06	14.0*	54.0
PQSCR	78.4	99.0*	53.4

***max value**

Interpretation of the coefficient values clearly demonstates that HIYRED is the most important explanatory variable. This observation is understandable since the structure of the variable is discrete, and that changes to adjacent values represents major distinctions in educational background. The example of shifting from a value of six to a value of seven, represents the difference of having a high school degree versus having gone to one year of college. In percentages of HIYRED, that constitutes moving from a large center group of high school qualified NCO's, to the upper ninety percent of the HIYRED distribution.

OAFQT is the second most significant explanatory variable. A shift of roughly one quarter of its range, i.e. 45 to 75, can change PRA plus or minus five percent. The other explanatory variables NCOE and PQSCR have considerably less influence on the dependent variable.

d. Checking of Assumptions

To verify the requirements for the regression model, residual analylsis was performed using the Grafstat program. Representative plots of the OAFQT residual are shown in Figures 4.18 and 4.19.

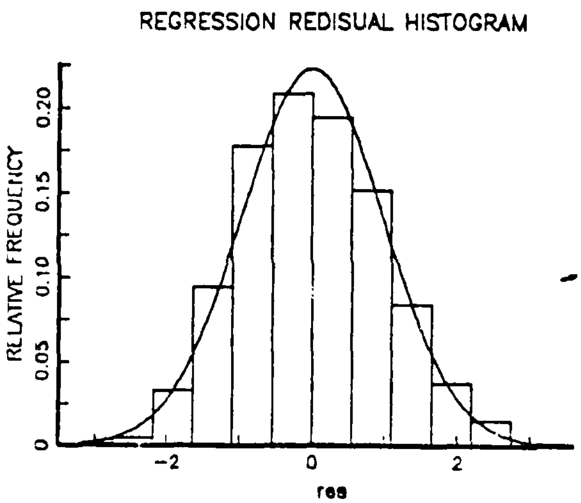


Figure 4.18

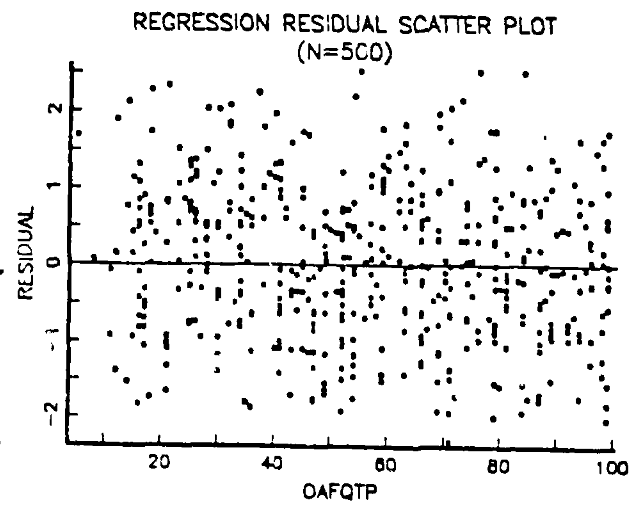
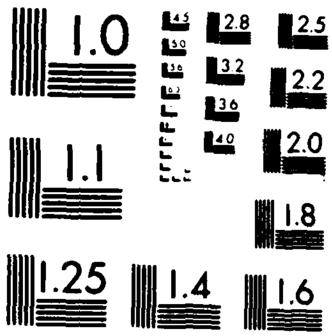


Figure 4.19

AD-A184 893 ANALYSIS OF INTELLIGENCE AND ACADEMIC SCORES AS A PREDICTOR OF PROMOTION (U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA J B WARNER 06 JUL 87 2/2

UNCLASSIFIED F/G 5/9 NL

END
11 87
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

The histogram of residuals, shown in Figure 4.18, demonstrates that the residual distribution is approximately normal. Homoscedasticity is checked in Figure 4.19, in which residuals have been plotted against the OAFQT variable. There does not appear to be any patterns in the plots of the residuals, and the uniform pattern was considered sufficient to justify the assumption of homoscedasticity. Lastly, since each observation represents a different person, the independence of each observation from one another is assumed true.

e. Confirmation of Regression Findings

(1) Second Data Set. Regression analysis was conducted on the second partition of the data set. A comparison of those results with the first data set is shown in Table XIX.

TABLE XIX Comparison of Regression Data Sets

Independent Variable PRA

	1st Set		2nd Set	
	Coeff	Std Err	Coeff	Std Err
Estimator				
OAFQT	.004260	(.00025)	.004729	(.00032)
HIYRED	.139483	(.00493)	.131559	(.00636)
PQSCR	.003272	(.00046)	.003197	(.00060)

The above results are felt to be sufficiently comparable to accept the original model coefficient scores.

(2) Nonparametric Regression. Since the model contained an ordinal variable, HIYRED, a regression result using nonparametric terms was included as a confirmatory

measure. Nonparametric regression produced the same linear least squares approximation for the model estimates, so the regression coefficient for HIYRED was still 0.1395. However, for nonparametric regression the test for the acceptance of the estimate value used the Spearman rank correlation coefficient. The regression coefficient for HIYRED was tested using this procedure.

First, for each value of PRA and HIYRED a predicted value U was found by computing U = PRA - (0.1395 * HIYRED). Then, the Spearman rank correlation coefficient, rho, was computed, based on the ranks of HIYRED and the ranks of U. It was found to be 0.02482 with a Pr>|R| of 0.0001. In this test the null hypothesis was the value of the regression coefficient was equal to 0.1395, the value found in regression. [Ref. 13:pp. 265-271] To test the null hypothesis, that the regression coefficient estimate is correct, rho was compared against a rejection region computed using the two tailed Spearman Quantile, with a normal approximation. The rejection regions for this Spearman Correlation parameter were values less than 0.0085 or greater than 0.9915. Since the value of rho did not fall inside either rejection region, the null hypothesis could not be rejected, and a HIYRED regression coefficient of .1395 was acceptable.

f. Testing the Model

The model coefficients found by regression were tested in two ways. First, a predicted promotion rate value was computed for the extremes and average of the model. The extreme values used the minimum or maximum values for the input variables. The average promotion rate was computed using sample averages for all input variables. The resulting predictions were then be compared against the actual distribution percentiles.

Secondly, subsets of the sample population had average promotion rates predicted using categorical values and sample population averages. The resulting predictions are compared against the actual sample values. Again percentile values for PRA were found by using a standard normal table approximation.

TABLE XX Comparison of Extreme and Average Predictions

Model		Data	
Minimum Prediction		**Sample Percentile**	
PRA Value	Percentile	PRA Value	Percentile
-1.0009	15.7%	-1.558	5%
(.1000)	(3.5%)		
Maximum Prediction		**Sample Percentile**	
PRA Value	Percentile	PRA Value	Percentile
1.23029	89.1%	1.7866	95%
(.4098)	(9.9%)		
Average Prediction		**Sample Percentile**	
PRA Value	Percentile	PRA Value	Percentile
0.01839	50.7%	-0.04146	50%
(0.223)	(8.5%)		

The model predictions were very accurate at the average level, but this accuracy diminished at the extremes.

The second test for the model was one where specific population subcategories had their average PRA value predicted. The subcategories represented were four combinations of SEX and the black and white RACETH variables. Additionally, predictions were made to check the average promotion rate of all NCO's with a HIYRED value of 10, and all NCO's with an OAFQT of 85. As in the previous table, unless the input variable is being used as a subcategory, its value was set to the overall population average. Table XXI shows the results of the predictions.

TABLE XXI Comparison of Predicted vs Actual PRA Averages

Subcategory	Predicted % (Lower-Upper)	Sample %	Sample Size
Male/White	55.1 (45.7-64.2)	53.1	18,003
Male/Black	49.5 (40.3-58.9)	44.3	12,121
Female/Black	47.3 (37.7-56.1)	47.7	2,485
Female/White	52.9 (44.1-61.5)	59.5	1,842
HIYRED=10	71.7 (63.5-79.3)	75.7	969
OAFQT=85*	57.4 (44.7-69.4)	60.2	2129

*The sample data point estimate was averaged over a range of OAFQT 80 to 90.

Testing of the regression model indicates that it was reasonably effective if used with input changes of the nominal variables, such as SEX and RACETH. Changes in the value of HIYRED produces reliable estimates, and demonstrated the considerable contribution of this variable as a predictor of PRA. The continuous variable OAFQT is difficult to test; since it is a continuous variable the model estimate was taken over a range of values. Predicted results are close to the sample value, but the variance of the estimate still spans the median. OAFQT does move the predicted values of PRA in the right direction, but its effectiveness is severely hampered by its variance and diminishing ability to provide an accurate prediction value as PRA approaches either extreme. Other prediction estimates were attempted using OAFQT and their results demonstrated the same lack of predictive ability away from the center percentiles.

g. Summary of Regression Analysis

Regression analysis provided estimates of the independent contribution of several key variables to predicting a promotion rate. They include a measure of intellgence aptitude, OAFQTP, a measure of academic ability, HIYRED, two measures of military performance, PQSCR and NCOE, and two nominal values SEX and RACETH.

Testing of these estimates shows that the predictive ability of the model is limited to those variables which have very distinct abilities to subcategorize the sample population. These variables are the SEX, RACETH, and HIYRED variables. The continuous variables for OAFQT, PQSCR, cannot be r[illegible] [illegible]d upon to independently yield estimates of PRA, but can [illegible] [illegible]ct limited shifts of the PRA distribution within a subcategory.

E. SUMMARY OF FINDINGS

Chapter IV was the principal analytical exercise in this study. It progressed through ascending stages of analysis and resulted in an inferential model with a restricted and independent set of explanatory variables. These explanatory variables did, in fact, rely on levels of intellegence tests and academic background as values to predict promotion.

The model, however, demonstrated only limited utility as a preditive equation. It could only match the sample data when it was describing an average promotion rate among a large population subcategory. This would occur only where the change in the explanatory variable had a significant partitioning effect on the population.

The next two chapters will investigate the relationship of intelligence and academic ability as a predictor of promotion rate but through different procedures.

V. ANALYSIS OF TOP PERFORMERS

A. INTRODUCTION

This chapter took an ad hoc approach to identify any trends which distinguish top performers, on the basis of promotion rate, from their peers. Top performers consist of the top three percent of the population, or 1,047 individuals, according to PRA scores. This data set was referred to as the TOP data set, while the remainder were referred to as the SAMPLE data set.

Analysis consists of three sections. The first section is a comparative tabulation of means and variances. Results shown in this section confirmed the majority of sample characteristics predicted in Chapter IV., such as higher EIMCAT and OAFQT scores. There were, however, discrepancies with respect to TOP distribution values of RACETH, NCOE and PAYGD. Those discrepancies are investigated in later sections of this chapter. The second section reports the results of formal hypothesis testing for differences in means between each of the explanatory variables. The last section investigates the discrepancies associated with RACETH, NCOE, and PAYGD. Through a presentation of graphics demonstrating internal shifts of those variable distributions, an effect which appears to interrelate the three distributional discrepancies is identified.

B. COMPARISON OF MEANS AND VARIANCE

The tabulated means and variances of the study variables for the top three percent and for the remainder of the entire sample are presented in Table XXII. The last column in the table shows the percentage and direction that the TOP data set differed from the SAMPLE.

TABLE XXII Top vs Sample Summary Data

Variable/Type	Top 3%		Sample		Comment
Promotion	Mean	Std Dev	Mean	Std Dev	
RATE	2.06	.392	0.00	1.00	
PRATE	.178	.037	.109	.036	
PRA	2.33	.350	0.00	1.00	
Intelligence					
AFQTP	64.69	22.01	53.4	20.9	Top 17.5% >
OAFQTP	61.60	23.24	45.3	24.7	Top 26.4% >
EIMCAT	6.11	1.31	5.07	1.28	Top 17.0% >
GTSCR	113.17	14.70	108.3	14.2	Top 4.1% >
HIYRED	6.88	1.59	6.01	1.07	Top 12.6% >
EDLVL	7.12	1.55	6.32	.97	Top 11.2% >
PQSCR	80.57	11.31	78.4	1.6	Top 2.6% >
NCOE	2.31	2.50	3.06	2.81	Top 33% <
Effects					
SEX	1.18	.390	1.12	.328	Top 5% >
CMF	62.09	27.146	51.9	31.3	Top 16% >
RACETH	1.58	.975	1.65	.942	Top 4% <
PAYGD	5.19	.405	5.27	.464	Top 3% <

Observations derived from the data in Table XXII can be summarized as follows:

The four aptitude test variables, GTSCR, AFQTP OAFQTP and EIMCAT, all demonstrate a strong positive difference between the TOP and SAMPLE scores. The AFQT related scores are about twenty percent greater, with GTSCR greater by four percent.

The variables, EDLVL and HIYRED, were both positive, with HIYRED slightly larger at twelve percent, PQSCR increased slightly.

The effects variables SEX and CMF both increased, with CMF demonstrating a significant increase. The change in CMF was an unexpected result of subsetting to the top three percent. The PRA variable was designed to be independent of CMF, and it should not have been affected as significantly as it was.

The only variables which decreased in proportion between SAMPLE and TOP were NCOE, RACETH, and PAYGD. Of the three, NCOE was the largest. The change in NCOE was also an unexpected result. Regression analysis indicated that NCOE had a positive influence on PRA. To have NCOE decrease with top performers is the reverse result. Paragraph D of this section will attempt to explain the reason for this anomaly.

C. SIGNIFICANCE TESTING

Significance testing for means of the explanatory variables between the TOP and SAMPLE data set was included as a formal statistical confirmation of differences between the two data sets. Testing using nonparametric methods was utilized since the study variables were either discrete, or if continuous, did not meet the Kolmogorov-Smirnov one-sample test for a normal distribution. The type of nonparametric test used is dependent on the type scale of the variable and whether it was continuous or discrete.

TABLE XXIII Top vs Sample Hypothesis Results

Variable	Test Used	Results	
Intelligence			
GTSCR	Kruskal-Wallis Test [1]	Chisq = 671	Strongly reject H0:
AFQTP	Kruskal-Wallis Test	Chisq = 1165	Strongly reject H0:
OAFQTP	Kruskal-Wallis Test	Chisq = 1418	Strongly reject H0:
EIMCAT	2XC Contingency Table[2]	Chisq = 503	Strongly reject H0:
HIYRED	2XC Contingency Table	Chisq = 931	Strongly reject H0:
EDLVL	2XC Contingency Table	Chisq = 700	Strongly reject H0:
PQSCR	Kruskal-Wallis Test	Chisq = 26.1	Reject H0:
NCOE	2 x C Contingency Table		
Effects			
SEX	2 * C Contingency Table	Chisq =	
CMF	2 * C Contingency Table	Chisq =	Strongly reject H0:
RACETH	2 * C Contingency Table	Chisq =	Reject H0:
PAYGD	2 * C Contingency Table	Chisq =	Strongly reject H0:

---

[1] For this nonparametric test the null hypothesis is that the populations are identical. The alternate hypothesis is that one of the populations yields larger observations. With two populations this is equivalent to a Mann-Whitney test. At a level α of .95 the critical Chisquare value for rejection is Chisq > 3.84.

2For this nonparametric test the null hypothesis is that the two populations have the same distribution as measured by the probability of falling into one of the discrete variable classifications. The alternate hypothesis is that the distributions are different. The contingency table is set for the two rows to be the classification of PRA > 1.93 and PRA $\leq$ 1.93, the C represents the number of discrete levels in the variable being tested. The Chisquare test statistic is also used for this test with a rejection of H0: when Chisq is larger than 3.84 at a .95 level α.

Hypothesis testing confirms the observations made on simple means and variances of the study variables. The strength of the difference can be interpretated by the magnitude of the Chi-square statistic.

D. ANALYSIS OF DISTRIBUTIONS

This section further investigates the shifts in distributions for those variables which conflicted with the relationships derived in regression and correlation analysis. Those variables were CMF, NCOE and PAYGD. Again, the conflicts which arose were two-fold.

First, neither CMF or PAYGD should have been affected by subsetting of the PRA variable. The PRA scores are normalized differences from the average score for every paygrade and CMF combination. Assuming a uniform application of promotion policy then, no one CMF or paygrade should have dominated as a result of subsetting to the top three percent. Secondly, NCOE should have increased slightly rather than decreased significantly by subsetting to the top three percent.

The three inconsistencies appear to be linked in their distributional change. Observation of the three Figures 5.1, 5.2, and 5.3. demonstrate this.

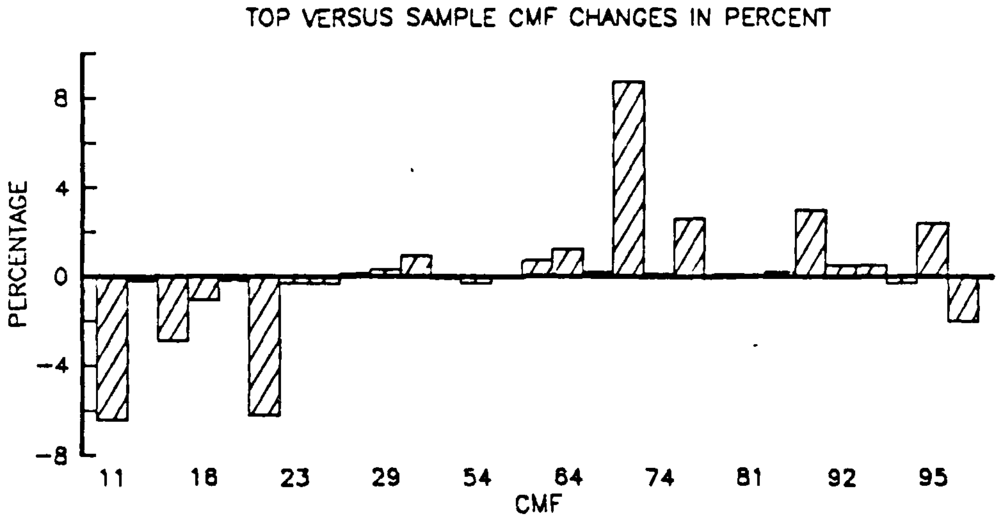


Figure 5.1

Figure 5.1 demonstrates a clearly defined redistribution of CMF percentages away from combat arms MOS's to the combat service support MOS's. In particular Infantry, Artillery, and Armor MOS's lost a total of 15.5 percent, while the Administrative Specialists (CMF 71) gained almost 9 percent.

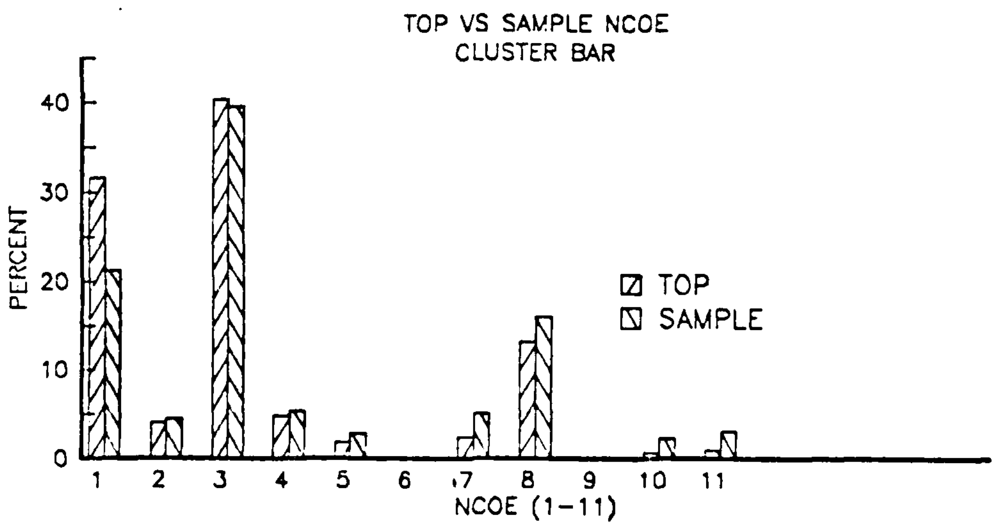


Figure 5.2

Figure 5.2 demonstrates transfer of a large percentage of the sample density away from the NCOE 7 to the NCOE 0 level. This was consistent with the observations in Figure 5.1, since only combat arms NCO's qualify for level 7, the Combat Arms Primary Leadership course.

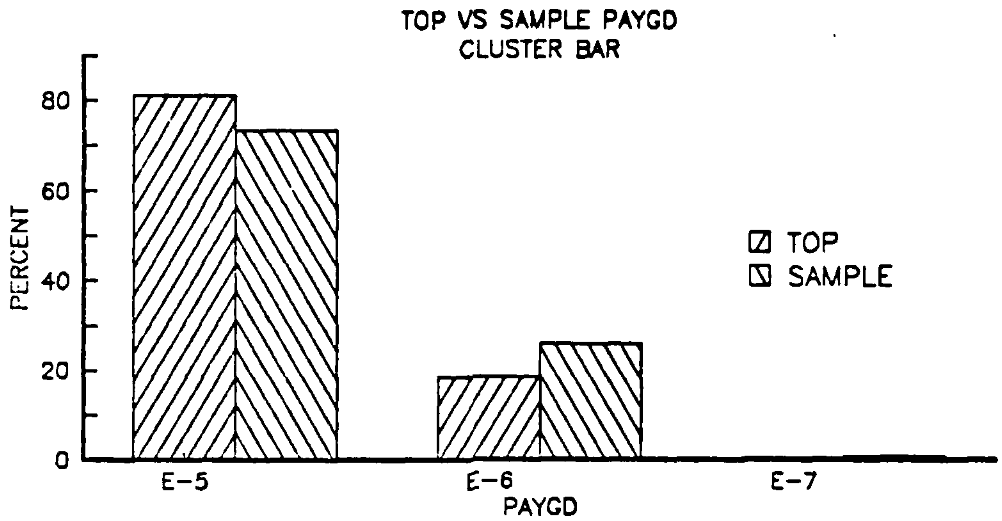


Figure 5.3

The last figure, Figure 5.3, shows a displacement of percentage from the E-6 to the E-5 paygrade as a result of extracting only the top three percent by measure of promotion rate.

To offer an explanation of the underlying reason for these discrepancies is difficult. Some measure of this discrepancy may well be explained in that the removal of effects by normalizing the PRA scores was not entirely adequate. The observed discrepancy may be simple mathematical error. However, it can be noted that their interrelationships do act consistently. Specifically, the reduction in paygrade and combat MOS's both combine to significantly reduce the NCOE level. As such, it is more likely that change in NCOE occured coincident with the changes in the two variables PAYGD and CMF. The effect being demonstrated was one where junior combat service support NCO's were dominating promotion achievement.

E. SUMMARY OF FINDINGS

Comparing the changes in averages for the top performers to the regression coefficients found in Chapter IV, shows very substantial agreement. Specifically, OAFQT was the most significant intelligence test variable, while HIYRED was the most significant academic variable. Although the percent change in OAFQT is greater than HIYRED, it still has considerably more variance than HIYRED. Thus, the predictive ability of HIYRED in regression should be more pronounced than that of OAFQTP. The less significant variables of PQSCR, SEX, and RACETH each shifted a small, significant amount in the appropriate direction.

The only discrepancy between the two procedures is the change in the variable NCOE. This change is felt to have been induced by changes in the CMF and PAYGD distributions. The effect is one where junior combat service support NCO's replace NCO's from the combat MOS's.

An important observation from analysis of the top three percent was that the increase in the value of any explanatory variable was not extreme. In fact, the largest increase was only twenty-five percent. As an inference, it appears that NCO's who do a little better in a combination of areas, rather than much better in a single area, are more likely recipients of faster promotion rates.

VI. PRINCIPAL COMPONENTS AND FACTOR ANALYSIS

A. INTRODUCTION

In this chapter more advanced statistical procedures are implemented to better summarize the independent variables, and improve or at least simplify the cause-effect model. Principal components and factor analysis are two closely related procedures which are normally used in investigating the mutual relationships and communalities of a large number of variables. By identifying redundant variables, and by constructing composite variables of the originals, it is possible to reduce the number of independent explanatory variables to only those which are significant and unique.

B. THEORY

Principal components and factor analysis each use matrix algebra to operate on a P by P matrix of correlation or covariance coefficients and produce system of eigenvectors of the form:

$Y_{(j)} = a_{1j}X_j + a_{2j}X_2 + ..a_{pj}X_p + E$. In the notation, $Y_{(j)}$ represents the resultant composite variable which is the linear combination of the loading coefficients, a_{ij}. These loading coefficients multiply each of the original variables X_n, n=1..p. E represents the amount of residual error not accounted by the linear model.[Ref. 5:p. 328] The resulting eigenvectors represent a set of orthogonal components jointly perpendicular in the space of the original variables. [Ref. 15:p. 424] These components are jointly uncorrelated and individually account for levels of variance, where the first principal component accounts for the largest proportion, and the last principal component accounts for the smallest. A resulting component may be representative of some aggregate characteristic of the original input variables. For example a resulting eigenvector which has strong factor loadings for original variables of physical strength and endurance could be called a factor of stamina as an aggregate measure. Principal components and factor analysis differ in that principal components assume and require that number of components equal to the number of initial variables is needed to account for the total variance. In contrast, the factor method assumes that there exists a set of composites in a dimension smaller than the dimension of the original number of variables which will suffice.[Ref. 5:p. 622]

An additional aspect of factor analysis is that it allows for rotation of the solution with the intent of developing more unique and well-defined components. For example if there are five variables in a factor which have intermediate loading factors in the range .2 to .4, a rotation of common factors by applying nonsingular linear transformations may result in a pattern matrix in which the loadings are either zero or close to one. The end result is easier to interpret than the factor with numerous mixed elements. Graphical measures are useful with the rotation procedure and allow the analyst to see the relative uniqueness of the input variables.

C. RESULTS

The SAS procedure for performing factor analysis was used with the method of factor determination being the principal component method. As such, basic principal component analysis was conducted, but limits were applied on the number of factors retained so that only the most significant composite factors would be kept. The first set of input variables included all of the twelve study variables. Table XXIV shows the resulting factor solution. Appended below each component is an interpretation explaining what the aggregate factors represent. The original input variables which contributed most to the factor have been underlined. Following Table XXIII is a factor plot, Figure 6.1, where each of the variables is coded by a letter. By observing the plot, any lack of uniqueness for a group of variables can be noted where the coded letters are close to one another.

TABLE XXIV Principal Components Tabular Results

Input Matrix of correlation coefficients
PRIOR COMMUNALITY ESTIMATES: ONE

	1	2	3	4	5	6	7
EIGENVALUE	4.0052	1.7334	1.4979	1.0634	0.8496	0.8028	0.7542
DIFFERENCE	2.2717	0.2355	0.4344	0.2138	0.0468	0.0486	0.2149
PROPORTION	0.3338	0.1445	0.1248	0.0886	0.0708	0.0669	0.0628
CUMULATIVE	0.3338	0.4782	0.6031	0.6910	0.7625	0.8294	0.8922

	8	9	10	11	12
EIGENVALUE	0.5392	0.3500	0.2809	0.1196	0.0034
DIFFERENCE	0.1892	0.0690	0.1613	0.1161	
PROPORTION	0.0449	0.0292	0.0234	0.0100	0.0003
CUMULATIVE	0.9372	0.9663	0.9897	0.9997	1.0000

7 FACTORS WILL BE RETAINED BY THE NFACTOR CRITERION

FACTOR PATTERN

	FACT1	FACT2	FACT3	FACT4	FACT5	FACT6	FACT7
EDLVL	.4302	.5861	.5024	-.2544	-.0624	-.0693	-.029
AFQTP	.9515	-.1133	-.1195	.0637	-.0075	.1548	-.024
EIMCAT	.9060	-.1220	-.1652	-.0598	-.0096	.1478	.011
NCOE	-.0085	-.4507	.6668	.2527	-.0398	.0084	-.134
HIYRED	.3834	.6410	.4176	-.3281	-.0637	-.0830	-.124
SEX	.1735	.4212	-.1113	.6516	.1857	-.0736	-.550
OAFQT	.9518	-.1046	-.1156	.0590	-.0092	.1535	-.023
GTSCR	.8238	-.1128	.0090	.0331	-.0464	.1350	.132
PQSCR	.4001	-.2413	.1205	-.1150	-.7312	-.4527	.115
CMF	.1677	.5200	-.1449	.4985	-.1171	-.2587	.561
PAYGD	.1216	-.3467	.6770	.3367	-.1816	-.0495	.151
RACETH	-.3590	.3130	.2547	.1229	.4708	.6507	.216
	Intell Tests	Acad	Career Status	Sex	PQSCR	RACE	CMF

FINAL COMMUNALITY ESTIMATES: TOTAL = 10.706622

```
        PLOT OF FACTOR PATTERN FOR FACTOR1 AND FACTOR3
                          FACTOR1
                         B  1
                       C G .9
                           .H
                           .7
                           .6
                           .5         A
                           .4 I      E
                           .3                 F
                        JF .2                 A
                           .1             K   C
-.9-.8-.7-.6-.5-.4-.3-.2-.1 0 .1 .2 .3 .4 .5 .6 D7 .8 .9
                          -.1                 T
                          -.2                 O
                          -.3    L            R
                          -.4                 3
                          -.5
                          -.6
                          -.7
                          -.8
                          -.9
                          -1
   EDLVL=A AFQTP=B EIMCAT=C NCOE=D HIYRED=E SEX=F
   OAFQT=G  GTSCR=H PQSCR=I CMF=J PAYGD=K  RACETH=L
```

Figure 6.1

The results appear to quite reasonable, wh[illegible]e most significant factor is a composite of all the ment[illegible]titude measures: OAFQTP, AFQTP GTSCR, and EIMCAT. The [illegible]cond factor consists primarily of academic performance measures EDLVL and HIYRED. The third factor is composed of NCOE and PAYGD and reflects two closely related measures dominated by paygrade. The fourth factor is predominantly a measure of SEX and two other nominal variables, CMF and PAYGD. The fifth, sixth and seventh factors all appear to be dominated by single variables, PQSCR, RACE, and CMF respectively.

In short, each of the original twelve variables is in some measure represented in the five factors, the first five factors accounting for over seventy five percent of the variance. By observing the entry for PROPORTION one can see that the subsequent seven factors each contributed between .0668 to .0028 of the variance and as such are not major contributors.

Using the results of the first solution a second analysis was conducted with a reduced number of input variables. In each of the initial solution factors the single variable having the largest loading factor was selected and the other related variables were eliminated. Table XXI shows the results of that solution, and Figure 6.2 shows the Factor Plot.

TABLE XXV Reduced Principal Components Tabular Results

PRIOR COMMUNALITY ESTIMATES: ONE
Input Matrix of correlation coefficients

	1	2	3	4	5	6	7
EIGENVALUE	2.1666	1.2063	1.0019	0.8703	0.8049	0.7081	0.2416
DIFFERENCE	0.9602	0.2044	0.1315	0.0654	0.0967	0.4665	
PROPORTION	0.3095	0.1723	0.1431	0.1243	0.1150	0.1012	0.0345
CUMULATIVE	0.3095	0.4819	0.6250	0.7493	0.8643	0.9655	1.0000

7 FACTORS WILL BE RETAINED BY THE NFACTOR CRITERION

FACTOR PATTERN

	FACT1	FACT2	FACT3	FACT4	FACT5	FACT6	FACT7
NCOE	.0221	-.5422	.6941	.2656	-.3801	-.1071	.018
HIYRED	.3659	.5302	.3135	-.5162	-.2443	-.4001	-.004
SEX	.1803	.6532	.1514	.6993	.0899	-.1346	-.051
OAFQT	.8945	.0404	-.0412	.0502	-.0668	.2462	-.328
GTSCR	.8592	-.0374	.0154	-.0492	-.1259	.3664	-.328
PQSCR	.5069	-.3707	.2537	-.0613	.7141	-.2648	-.022
RACETH	-.4521	.3275	.5799	-.1589	.2487	.5031	.037
	Intell Tests	Acad	NCOE	SEX	PQSCR	Race	

FINAL COMMUNALITY ESTIMATES: TOTAL = 7.000000

NCOE	HIYRED	SEX	NOAFQT	GTSCR	PQSCR	RACETH
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

```
                PLOT OF FACTOR PATTERN FOR FACTOR1 AND FACTOR2

                                 FACTOR1
                                    1
                                 E.9D
                                   .8
                                   .7
                                   .6
                    F              .5
                                   .4          B
                                   .3                        F
                                   .2                C       A
                                   .1                        C
 .9-.8-.7-.6A.5-.4-.3-.2-.1  0 .1 .2 .3 .4 .5 .6 .7 .8 .9    T
                                 -.1                         O
                                 -.2                         R
                                 -.3                         2
                                 -.2
                                 -.4    G
                                 -.5
                                 -.6
                                 -.7
                                 -.8
                                 -.9
                                 -1

NCOE=A  HIYRED=B SEX=C  OAFQT=D  GTSCR=E  PQSCR=F RACETH=G
```

Figure 6.2 Factor Plot

Restricting the input to the strongest unique variables results in an almost complete separation into single factors. The only exception is the grouping of GTSCR and OAFQT, (E and D). This is not suprising considering the composition of both scores from the same set of tests in the ASVAB. Thus, the decision to eliminate GTSCR from earlier regression models makes sense from the Factor Analysis perspective as well.

E. SUMMARY OF FINDINGS

The application of principal components and factor analysis confirmed many of the patterns of dependency and redundancy with the study variables. It confirmed the choices for unique variables in the regression as developed in Chapter IV, and gave a good second opinion for deciding which variables could be set aside with little effect on the model.

VII. CONCLUSION

A. OVERALL FINDINGS

There is strong statistical evidence to support the proposition that success in the Army, as measured by promotion rate, is related to the individual's intelligence test scores and previous academic background. The explanatory variables of the 1980 normed AFQT score and the individual's highest year of education at time of entry are the most important indicators for a future promotion rate. The highest year of education at time of entry is the more important measure, but changes in its discrete scale represents very substantial changes in academic background. OAFQT is not nearly as important as HIYRED and can independently affect the predicted promotion rate only up to ten percent.

While in service, how well the individual scores on his Performance Qualification Test Scores and his attendance at NCO schooling will be indicative of a faster promotion rate.

The statistical evidence for these observations can be argued by showing the existence of significantly increasing promotion rate averages across ascending levels of explanatory measures in ANOVA and ANCOVA analysis. This argument can be supplemented, and those differences seen more concretely, by a simpler comparison of top performers verses the sample averages.

Considerable variance of promotion rate exists across any of the levels of the discrete explanatory variables, and within any of the categorical variables. There is a dilemma in designing an effective dependent variable. While controlling categorical variables such as CMF and Paygrade, the effects of the other variables become more apparent and significant. However, the ability of the model to explain variance is significantly diminished.

Selecting a set of the most important and unique explanatory variables was achieved via two methods. A successive, increasing dimension procedure distilled a set of unique explanatory variables. This method relied upon developing detailed familiarity with each variable. In the process hypothesis testing was used to eliminate insignificant contributors and identify the most important variable from a group of related variables. This restricted set of explanatory variables was confirmed with the use of principal components, a method which uses a mathematical approach to identify orthogonal and unique variables.

When using inferential procedures the resulting model met regression assumptions, both parametrically and nonparametrically. Further, the model estimates are reproducable with an alternate data set.

Although the model is technically acceptable, it is only accurate in predicting promotion values for population subcategories. The low R2 value and high mean square error terms found during regression were manifested in model testing. When making predictions based on incremental changes in AFQT the sample data values were close, but upper and lower bounds were so large that resulting predictions were not usefull.

The poor performance of the predictive model can be attributed to two possible reasons. First, that there exists some unspecified predictor variable which could be used to better account for variance. Or secondly, there exists significant inexplicable chance in the occurance of a promotion rate for any given individual.

In the case of the first reason, it should be observed that the number of available entries held on a given individual at either DMDC or MILPERCEN is limited. Of the one hundred and forty data fields, this study considered all entries which were felt to have potential merit as an explanatory variable. This included several versions expressing the same fundamental quality. Of the twelve variables considered the final number of significant variables was reduced to only six. Overall, there are few significant and unique measures available to use as predictors. To discover additional explanatory variables would require establishment of new personnel data elements in those data bases. Potential candidates include evaluation report averages, or possibly, the results of a personality composite test. Alternatively, the quality of information on academic performance could be increased, such as the inclusion of grade averages from high school attendance periods. The utility of this additional data would then have to be evaluated in a manner similar to this thesis.

The second reason given for error is a more probable explanation, for the subject matter of this study is people, and not a more deterministic physical phenomenon. The resolution of a cause effect relationship is more subtle and more difficult to verify. Although this condition does not have a mathematical remedy, the judgement of whether or not even a small, highly variable measure of trend is sufficient still lies with the analyst and his ability to present that judgement to decision makers.

B. POLICY RECOMMENDATIONS

The first question that must be answered in this section is whether or not having a predictive model is necessary to make policy decisions regarding promotion or accession. The answer offered in this document is that it is not. There is sufficiently reliable information resulting from hypothesis testing and subpopulation analysis to make cogent observations and decisions with.

From the results of this investigation, accession policy makers should closely manage the two attributes of OAFQT and HIYRED. This recommendation is more a confirmation, rather than a proposal. The 1984 Defense Authorization Act already places constraints on AFQT category and high school diploma status.

The two in-service attributes that should be managed are the Performance Qualification Score, and attendance at NCO schooling. To directly tie scores on these attributes in the form of promotion points or a minimum threshold scale would be one approach. Unfortunately, this may artificially force NCO's of less potential and aggressiveness into categories with the more competent individuals. The result may be a lessening of the discriminatory effectiveness of the two measures.

If the individual were allowed to achieve his or her score and pursue in-service education independent of promotion policy, the ability of these variables to discriminate would be better. However, not tying these scores directly to promotion points values or thresholds should not mean that either measure would be unused. A policy where promotion boards were still instructed to review an individual's scores, inclusive with notification of this review policy to the NCO population allows for self selection by the more ambitious individuals.

C. SUGGESTIONS FOR FURTHER RESEARCH

One disturbing observation of this study was the apparent disparity among race and ethnic groups in terms of AFQT and promotion rates. As pointed out by Daula (1985) the explanation of this disparity cannot be seen in an aggregate promotion data approach, but rather, a duration model approach with a set group of individual soldiers over time.[Ref. 11:pp. 7-9] His paper reports that this disparity is a result of attrition. Specifically, the shifting of subcategory promotion averages is a result of different retention patterns among race and ethnic groups, and not due to a racialy sensitive promotion system.

A study to determine the magnitude and underlying reasons for the different retention patterns, and to test this hypothesis, would have considerable merit.

APPENDIX A

CAREER MANAGEMENT FIELDS AND FREQUENCIES

MOSNAME	CMF	FREQUENCY	PERCENT	CUMULATIVE FREQUENCY	CUMULATIVE PERCENT
Infantry	11	4320	11.4	4320	11.4
Cbt Engineer	12	1030	2.7	5350	14.1
Artillery	13	2780	7.3	8130	21.5
Air Defense	16	851	2.2	8981	23.7
Special Ops	18	244	0.6	9225	24.4
Armor	19	2434	6.4	11659	30.8
Hawk Missile	23	187	0.5	11846	31.3
Nike Missile	27	352	0.9	12198	32.2
Tac Radar	28	40	0.1	12238	32.3
Tac Radar	29	625	1.7	12863	34.0
Communication	31	3265	8.6	16128	42.6
Elect Warfare	33	30	0.1	16158	42.7
Tech Drafter	51	619	1.6	16777	44.3
Chem Warfare	54	529	1.4	17306	45.7
Explosive Ord	55	400	1.1	17706	46.8
Repair	63	3766	9.9	21472	56.7
Cargo Spec	64	1041	2.8	22513	59.5
A/C Repair	67	1090	2.9	23603	62.4
Admin Spec	71	3020	8.0	26623	70.3
Programmer	74	423	1.1	27046	71.4
Supply	76	2677	7.1	29723	78.5
Recruiter	79	106	0.3	29829	78.8
Topo Eng	81	65	0.2	29894	79.0
AV Spec	84	157	0.4	30051	79.4
Medical	91	2498	6.6	32549	86.0
Lab Spec	92	444	1.2	32993	87.2
Air Traffic	93	175	0.5	33168	87.6
Food SVC	94	919	2.4	34087	90.0
Mil Police	95	1674	4.4	35761	94.5
Intelligence	96	789	2.1	36550	96.6
Musician	97	176	0.5	36726	97.0
EW/SIGINT	98	1125	3.0	37851	100.0

APPENDIX B

AFQT TRANSFORMATION EQUIVALENT SCORES

Armed Forces Qualification Test (AFQT)
Equivalent Percentile Scores for 1944
Mobilization Population and 1980 Youth Population

1944	1980	1944	1980	1944	980
1	1	34	33	67	66
2	1	35	34	68	67
3	2	36	35	69	68
4	2	37	35	70	69
5	3	38	36	71	70
6	4	39	37	72	71
7	5	40	38	73	72
8	6	41	38	74	73
9	6	42	39	75	74
10	8	43	40	76	75
11	8	44	41	77	76
12	10	45	42	78	77
13	11	46	42	79	78
14	12	47	43	80	79
15	14	48	44	81	80
16	15	49	46	82	81
17	16	50	47	83	83
18	17	51	48	84	84
19	18	52	49	85	85
20	19	53	49	86	87
21	21	54	50	87	89
22	22	55	51	88	91
23	23	56	52	89	92
24	24	57	53	90	93
25	25	58	54	91	94
26	26	59	56	92	95
27	26	60	57	93	95
28	27	61	58	94	97
29	28	62	59	95	98
30	29	63	60	96	98
31	30	64	62	97	99
32	31	65	63	98	99
33	32	66	65	99	99

LIST OF REFERENCES

1. Torgerson, W.S., Theory and Methods of Scaling, John Wiley & Sons, Inc., 1958.

2. Douglas, B.A., An Analysis of the Academic Composites of the Armed Services Vocational Apritude Battery (ASVAB) and the Math and Verbal Sections of the Preliminary Scholastic Aptitude Test (PSAT), the Scholastic Aptitude Test(SAT), and the American College Test (ACT): A Correlation Study, PH.D Dissertation, Southern Illinois University at Carbondale, 1986.

3. Jenson A.R., Test Reviews, ASVAB, in Measurement and Evaluation in Counseling and Development, University of California, Berkely, April 1985.

4. SAS Institute Inc., SAS User's Guide: Basics Version 5 Edition, SAS Institute Inc., 1985.

5. SAS Institute Inc., SAS User's Guide: Statistics Version 5 Edition, SAS Institute Inc., 1985.

6. IBM Research Yorktown Heights., GRAFSTAT Introductory Manual, June 1986.

7. Schatzoff, M., and others. Regression Analysis in GRAFSTAT, IBM Yorktown Research Center, June 1986.

8. Scribner, B.L., and others. Are Smart Tankers Better? AFQT and Military Productivity, pp. 193-206, Armed Forces & Society, Vol 12 No 2., Winter 1986.

9. Dunbar, S.B., and others. On Predicting Success in Training for Males and Females: Marine Corps Clerical Specialties and ASVAB Forms 6 and 7, Cada Research Group, The University of Iowa, February 1985.

10. Department of Defense, Office of the Assistant Secretary of Defense (Manpower, Installations, and Logistics)., Report to the House and Senate Committees on Armed Services Defense Manpower Quality, Volume II Army Submission, May 1985.

11. Daula, T. Estimating Time to Promotion for Promotion for Enlisted Soldiers, Paper presented at The Information Management/Operations Research Society of America Conference, Boston, MA., July 1985.

12. Chambers, J.M., and others., Graphical Methods for Data Analysis, Wadsworth, 1983.

13. Conover W.J., Practical Nonparametric Statistics, John Wiley & Sons, Inc., 1971

14. Baldwin R.H., Documenting Personnel Quality Requirements with Statistical Analysis, United States Military Academy, December 1985.

15. Berenson, M.L. and others, Intermediate Statistical Methods and Application, A Computer Package Approach, Prentice-Hall, Inc., 1983.

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Technical Information Center Cameron Station Alexandria, Virginia 22304-6145	2
2.	Library, Code 0142 Naval Postgraduate School Monterey, California 93943-5002	2
3.	Superintendent, Code 55Lw Attn: Prof. P.A.W. Lewis Naval Postgraduate School Monterey, California 93943-5000	1
4.	Superintendent, Code 55La Attn: Prof. Larson Naval Postgraduate School Monterey, California 93943-5000	1
5.	HQDA, ODCSPER ATTN: DAPC-ZXP (Ltc. Helmick) The Pentagon Washington, D.C. 30310-0300	2
6.	Cpt. Jim Lewis SMC 2096 Naval Postgraduate School Monterey, California 93943-5000	1
7.	Cpt. Jerry B. Warner 6724 Danforth St. McLean, Virginia 22101	1

END

10-81

DTIC