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THESIS

AN ECONOMETRIC ANALYSIS OF THE EFFECT OF FULLY-FUNDED GRADUATE EDUCATION ON PERFORMANCE FOR SURFACE WARFARE OFFICERS

by

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March, 1994

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An Econometric Analysis of the Effect of Fully-Funded Graduate Education on Performance for Surface Warfare Officers

by

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ABSTRACT

This thesis analyzes the impact of the Navy's fully-funded graduate education program on Surface Warfare Officer performance. Three measures of officer performance are used: (1) probability of promotion to O-4; (2) percent of all LT FITREPs recommended for early promotion; and (3) the probability of receiving an early promotion recommendation on the last LT FITREP. Navy Officer Master Files (FY1981 through FY1990), created by Prof. William Bowman, USNA, are merged with NPRDC's Officer FITREP Files to statistically analyze performance differences between Surface Warfare Officers with and without fully-funded graduate education. Ordinary least squares and non-linear maximum likelihood techniques are used to estimate the three performance models. Since selection into the fully-funded program is not random, an attempt is made to model the selection process and to correct for the potential bias in the estimated coefficient of graduate education in the performance models. The findings reveal that fully-funded graduate education has a significant positive impact on the probability of promotion to O-4, but insignificant effects on receiving early promotion recommendations on LT FITREPs. Additionally, selectivity does not appear to bias estimates of fully-funded graduate education in the performance models.

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I. INTRODUCTION

> Graduate education is both a noble idea, and an ongoing necessity that enhances the quality leadership essential for the United States Navy. I believe graduate education is one of the tools absolutely required for officers who will face growing complexities in technological, managerial and political/economic fields in the Navy. Even in this era of fiscal austerity and competing requirements placed upon our junior officers, investment in graduate education must be pursued as a priority. [Ref. 1:p. 6]
>
> -- ADM Frank B. Kelso,II, Chief of Naval Operations, on graduate education policy.

A. BACKGROUND

Today's highly competitive economic environment, combined with a rapid rate of technological advancement, has placed new emphasis on smaller, yet more productive labor forces in both civilian and military organizations. Graduate education has emerged as a viable means to "retool" mid-grade managers and officers with the required knowledge and skills to succeed in this challenging and rapidly changing environment.

As the value of graduate education for both the employer and the recipient continues to increase, and in light of the current reductions in Navy officer end strength and defense appropriations, it is important to estimate the true value of graduate education to both the Navy and the recipient. The theory of human capital investment, discussed in detail in Chapter II, suggests that formal education increases productivity and earnings of an individual over time. In the civilian labor force, returns to education may be measured by increased earnings. In the military, returns to education may be measured by increased earnings as a result of promotion (which is infrequent), and with length of service within grade. Thus, changes in productivity can be measured by changes in performance within and across rank, and alternatively by longer job tenure - or years of service - as a measure of an additional contribution to the Navy. [Ref. 2]

This study analyzes the impact of graduate education that is fully-funded by the Navy on Surface Warfare Officers (SWO) utilizing two measures of performance: promotion to Lieutenant Commander (O-4) and performance on Lieutenant fitness reports (FITREPS). Two aspects of the LT FITREPs are used: (1) the percent recommended for early promotion (RAP), and (2) whether or not the final LT FITREP (just prior to the O-4 selection board) receives an early promotion recommendation. The focus here is on job performance, rather than job tenure, as the latter is no longer critical to the Navy in an environment of reduced end strength.

The officer data file used in this thesis is based on the Officer Promotion History Data File (FY's 1981 through 1990) obtained from Dr. William R. Bowman of the U.S. Naval Academy (USNA), and the Officer Fitness Report Files from the Naval Personnel Research and Development Center (NPRDC), San Diego. Figure 1, which is derived from these two data sources, reveals that Surface Warfare officers with fully-funded graduate education (FFGE), when compared to all other SWOs, were promoted 17 percentage points higher, received 10 percent more recommendations for early promotion on all LT fitness reports, and were 5 percent more likely to receive an early promotion recommendation on the last LT FITREP.

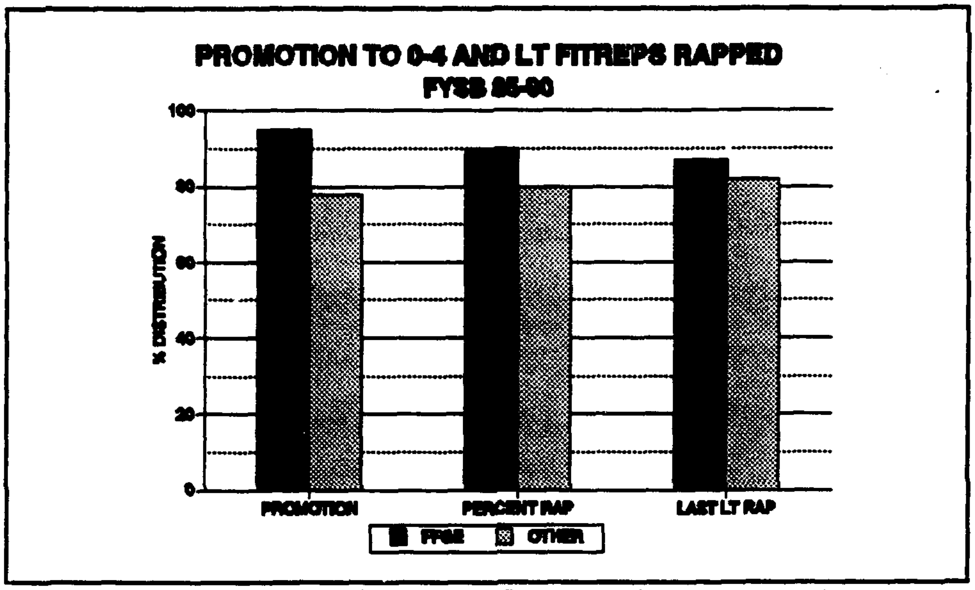

Figure 1. Promotion, and LT fitrep performance distribution of fully-funded graduate educated versus all other Surface Warfare Officers (FY 85-90).
Source: USNA and NPRDC.

The question that remains to be answered is how much of these differences in performance between graduate educated and non-graduate educated SWOs is due to:

1. An increase in productivity attributed to graduate education and the increased stock of human capital;
2. Observed demographic characteristics, undergraduate experience, or Navy experience;
3. Unobserved factors accounting for the fact that officers selected for graduate education are already established

as top performers and are inherently more promotable due to motivation, innate ability, desire for achievement, contacts, health, attitudes, and interests.[1]

To fully understand the implications of graduate education on performance, one must first understand the various graduate education opportunities afforded Naval officers and the requirements for each. Officers who attend graduate school full-time under any partially or fully-funded program of 26 weeks or more are considered funded. Funded programs are limited to providing sufficient officers with subspecialties to fill validated billet requirements. Officers may pursue fully-funded graduate education at the Naval Postgraduate School (NPS), Monterey, CA or at selected Department of Defense (DOD) and civilian institutions (CIVINS). [Ref. 3] The officer receives full pay and allowances with the majority of tuition and other schooling costs being assumed or paid by the Navy. The officer attends school instead of performing usual military duties. [Ref. 4] The officer agrees to obligate himself or herself to active duty equal to a period three times the length of education through the first year and one month for each month thereafter. Officers receiving fully-funded degrees are required to serve one tour in a

[1] As discussed in more detail below, a major problem with estimating returns to graduate education is the "selection bias" that results from individuals who self-select and/or are selected by the Navy for graduate education, who would later be more likely to promote even in the absence of graduate education.

validated subspecialty position as soon as possible but not later than the second tour following graduation. [Ref. 3]

In a partially funded program, the officer receives full pay and allowances with the majority of tuition and other schooling costs paid by the officer. As with the fully-funded program, the officer attends school instead of performing usual military duties, incurs the same active duty obligation, and is to serve in a validated subspecialty tour within the same period. [Ref. 4]

Graduate education through the tuition assistance (T/A) program is pursued by the officer during off-duty time while receiving full pay and allowances. The officer receives 75 percent of tuition costs from the Navy for one degree program only, which is based on a certain amount of money per credit hour and is capped on an annual basis. This program allows the officer to choose his/her area of study and incurs a two year obligation upon completion. [Ref. 5]

Unfunded graduate education is pursued by the officer during off-duty time and all costs are incurred by the officer. No additional active duty obligation is incurred and an officer may or may not receive a validated subspecialty. Officers are free to pursue any area of study desired. [Ref. 4]

B. OBJECTIVE

The objective of this thesis is to obtain accurate estimates of the impact of fully-funded graduate education on two measures of performance, promotion to O-4 and LT FITREP performance, broken down into the percentage of all LT fitness reports recommended for early promotion and whether the last LT FITREP receives an early promotion recommendation for Surface Warfare officers. Utilizing multivariate modeling techniques, the intention is to isolate performance differences between SWOs with and without fully-funded graduate education, and to apply standard techniques to correct the estimates for selection bias. The ability to test and correct for potential selectivity bias associated with graduate education selection depends on how effective the selection model is in its predictions.

The Navy's investment in fully-funded graduate education is significant. In 1994, the annual cost for fully-funded graduate education programs is projected to ve approximately $174.5M. [Ref. 5] The results of this analysis will address what the payoff is to the Navy from its significant investment in graduate education, and whether or not removing an officer from the surface warfare environment to obtain a graduate education is career-enhancing to the officer.

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

The data set used to define the research population, originally created by Professor William R. Bowman of the Naval Academy, contained all officers going before the promotion selection board for Lieutenant (O-3) between fiscal years 1981 and 1985 and Lieutenant Commander board (O-4) between fiscal years 1985 and 1990. This data set is merged with fitness report files (supplied by NPRDC) to allow the researcher to track an officer's performance from the time of commissioning through selection to O-4, or until the officer separated from the Navy.

Due to differences in how different communities evaluate officers, and sharp differences in career paths between communities, only one Unrestricted Line (URL) community was chosen as the subject of this research effort. The Surface Warfare Officer (SWO) community was chosen because of its highly structured career path and the fact that SWOs comprise a majority of URL officers.

To ensure there were no missing values for any variables, only SWOs with complete data on all variables used in the regression models were included in the analysis.[2] Officers transferring into the SWO community were included in the analysis because most of these transitions occur very early in one's career, and well before the LT selection board.

[2] This process resulted in only 283 observations, or 15 percent, of the original sample being excluded from the study.

Officers leaving the SWO community were not included in the population and were automatically removed from consideration.[3]

In an effort to maintain consistent measures of the impact of graduate education on performance and due to the fact that officers with fully-funded graduate education comprise 84 percent of all those with graduate education in the sample, the "treatment group" is restricted to only those officers with fully-funded graduate educations. Considering the significant investment incurred by the Navy in providing fully-funded graduate education, restricting the treatment group to those with fully-funded education (FFGE) will focus on the group with the greatest importance to graduate education policy makers. Since Naval Postgraduate School (NPS) graduates constitute 96 percent of all FFGE's in the sample, NPS and FFGE may be considered synonymous in this study.

The Master Loss File is available in the data, but nearly all who left the Navy prior to the LCDR selection board did not have fully-funded graduate degrees. Because fully-funded graduate degree recipients incur an additional obligation averaging four years, it was decided not to attempt to analyze retention behavior. However, officers deciding to remain in the Navy beyond initial obligation may differ systematically

[3] This resulted in only 147 observations that were excluded from the study.

from those choosing to leave. The factors that are associated with these differences could be important to performance and promotion. This separation decision is considered an important level of selection prior to the O-4 promotion board and it is analyzed in the appendix.

Three performance measures are used in this thesis:

1. probability of promotion to O-4;
2. percent of all LT FITREPs receiving an early promotion recommendation;
3. probability of receiving an early promotion recommendation on the last LT FITREP.

This thesis analyzes promotion and whether the last LT FITREP receives a recommendation for early promotion (RAP) in a binary fashion utilizing nonlinear regression (logit) models. The measure of the percent of all LT FITREPS that receive "RAPs" is analyzed in a linear fashion utilizing an ordinary least squares (OLS) regression technique.

Selection for fully-funded graduate education is modeled in a binary fashion utilizing a nonlinear, maximum likelihood (probit) estimating procedure. This statistical technique produces estimates of the likelihood of graduate education selection for each officer in the sample. The contention that officers selected for graduate education are inherently more productive and perform at a higher level suggests that there are some unobserved (unmeasurable) factors related to performance outcomes. Multivariate regression analysis captures these unobservables in an error term. If a significant correlation exists between this error term and the graduate education independent variable, the estimates of the impact of graduate education on officer performance will be "biased." In this case, the presence of selectivity bias could cause the estimated coefficient of graduate education to overestimate its true impact on the three performance measures.

In order to obtain accurate estimates of graduate education, two different procedures -- referred to as "the Heckman" and "the Barnow" approaches -- are used to correct for potential selectivity bias in the measures of performance. Critical to the effectiveness of these procedures is the assumption that selection for graduate education is not random and the degree of success associated with the ability to accurately predict selection will determine if selectivity bias is important. These procedures will be discussed in more detail in Chapters II and III below.

D. ORGANIZATION OF THE STUDY

This study is organized into five chapters. Chapter II reviews pertinent literature and previous studies relevant to human capital investment theory, military promotion, the use of fitness reports as measures of performance, and selectivity bias. Chapter III describes the data sets used in the thesis and discusses the specification of the various multivariate models to be estimated. Chapter IV presents the empirical results of bivariate and multivariate analyses of the models. Chapter V summarizes the results, and provides conclusions and recommendations on further research.

II. LITERATURE REVIEW

This chapter includes reviews of relevant previous research efforts in four different areas relevant to this thesis. These areas include: human capital investment theory, research on personnel promotion, research on officer performance (FITREPs), and analyses of selectivity bias.

The costs and benefits associated with an investment in graduate education can be sizable for both the provider and recipient. Although the Navy incurs much of the monetary cost for fully-funded programs, there are non-monetary costs that the officer must weigh in his or her decision to pursue graduate education. Human capital investment theory provides a framework for identifying the relevant costs and benefits.

Previous research on assessing the impact of graduate education on employee promotion and performance is extremely limited. Two studies of promotion were chosen for the literature review in this chapter on the basis of relevance and similarities to independent variables used in this thesis. Other research efforts on performance that utilized fitness reports are also reviewed because they provide the basis for the development of the FITREP performance indexes used in this thesis. Finally, given that potential selectivity bias is an underlying theme throughout this thesis, it is important to define the nature and the effects of selectivity in the analysis of graduate education, and how it can be accounted for in statistical models of officer performance.

A. HUMAN CAPITAL INVESTMENT THEORY

Capital investments, by definition, entail an initial cost that the investor hopes to recoup over some future period of time. Traditionally, capital investments were considered in terms of nonhuman assets such as, land, buildings, and machinery. However, a relatively new use of "human capital" has given investment a new meaning. Human capital investments include such activities as education, job training, and migration.[4] All three incur initial costs and are made with the expectation that the investment will pay off well into the future in the form of higher productivity (and therefore earnings), reduced job turnover, and increased job satisfaction. [Ref. 6] For the purposes of this study, only one type of human capital investment will be discussed, that of formal education.

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[4] Human capital investment in <u>education</u> incur initial costs to the employer (provider) through tuition and forgone productivity by the employee during education.

Human capital investment in <u>job training</u> intends to provide increased skills to workers, resulting in higher productivity/earnings.

Human capital investment in <u>migration</u> refers to voluntary (job quitting) and involuntary lay-offs. Costs incurred by the employee are induced by earnings lost during the search for new employment and relocation. [Ref. 6]

This thesis concentrates on the Navy's investment in its fully-funded graduate education program. The increased knowledge and skills associated with graduate education represent an increase in the recipient's stock of productive capital. In the civilian labor market, an increase in one's human capital is typically measured by an increase in earnings, as more precise data on individual productivity is not available. [Ref. 6] In the military, individual performance can be measured, which allows the researcher to estimate more clearly the returns to human capital compared to the multitude of human capital research in the civilian labor market.

Three main elements of human capital investment theory are central to this study: (1) whether the training (or education) is specific or general; (2) the means of financing; (3) and the timing of the investment. First, human capital investments in graduate education may be *general* or *specific* in nature. General education (or training) increases an individual's productivity to many employers equally, including the Navy, whereas specific education increases an individual's productivity only to the Navy (or the firm in which he or she is currently employed). [Ref. 6] The majority of course work in a civilian master's degree in Business Administration (MBA) is general in nature due to its value to a wide variety of employers. Certain required courses within the Navy's fully-funded graduate education programs, not available in civilian graduate programs, are designed by Navy sponsors and are "firm specific" to the Navy. These military courses may lessen the attractiveness of the program to private sector employers compared to civilian graduate programs. Further more, some fully-funded graduate programs, like Anti-Submarine Warfare offered at the Naval Postgraduate School (NPS) is wholly specific to the Navy. In general, curricula offered through the Navy's fully-funded programs emphasize specific naval applications, but as with any accredited academic institution, a plethora of subjects taken by the students are general in nature. To the extent that a graduate degree has general components, the recipient becomes more marketable for lucrative civilian job opportunities. Since the individual's potential civilian wage rises, a graduate degree tends to increase his or her probability of leaving the Navy. To offset this, the Navy imposes an additional service obligation accompanying a fully-funded graduate education. This binds the individual to the Navy and ensures that the Navy receives some return on its investment.[5]

The second element central to this study is the means of financing the graduate education investment. For education that is general in nature, the increase in an employee's

[5] The return is in the form of having a more "productive" officer fill specialized billets and in reducing turnover costs associated with having to hire and train less experienced workers/officers.

marginal productivity after graduate education forces firms to pay a wage equal to or greater than the value of the increased productivity. Otherwise, the employee will choose to work for another firm willing to pay the higher wage. Since most graduate education programs contain both general and specific elements, costs incurred by the employer play an essential role in the decision to provide graduate education opportunities. Consequently, either firms will not offer graduate education, or will force the employees to bear a portion of the education costs by paying them wages below the marginal product (by an amount equal to the education cost) in the post-education period. [Ref. 6] Figure 2 illustrates this marginal product/earnings relationship.

In contrast to the dilemma faced by civilian firms, the military is somewhat unique in that it can pay the full cost of graduate education and recover the investment through extended service obligations, during which the service member is paid the same pre-graduate education wage. In economic terms, the military is able to acquire a "surplus" by paying the officer a wage less than the value of his or her gain in marginal productivity. On the other hand, there is an indirect cost, commonly referred to as "opportunity cost," suffered by the military through foregone productivity of the officer in the fleet during graduate education. The military is willing to fund graduate education only if the increased marginal benefit gained through graduate education exceeds the

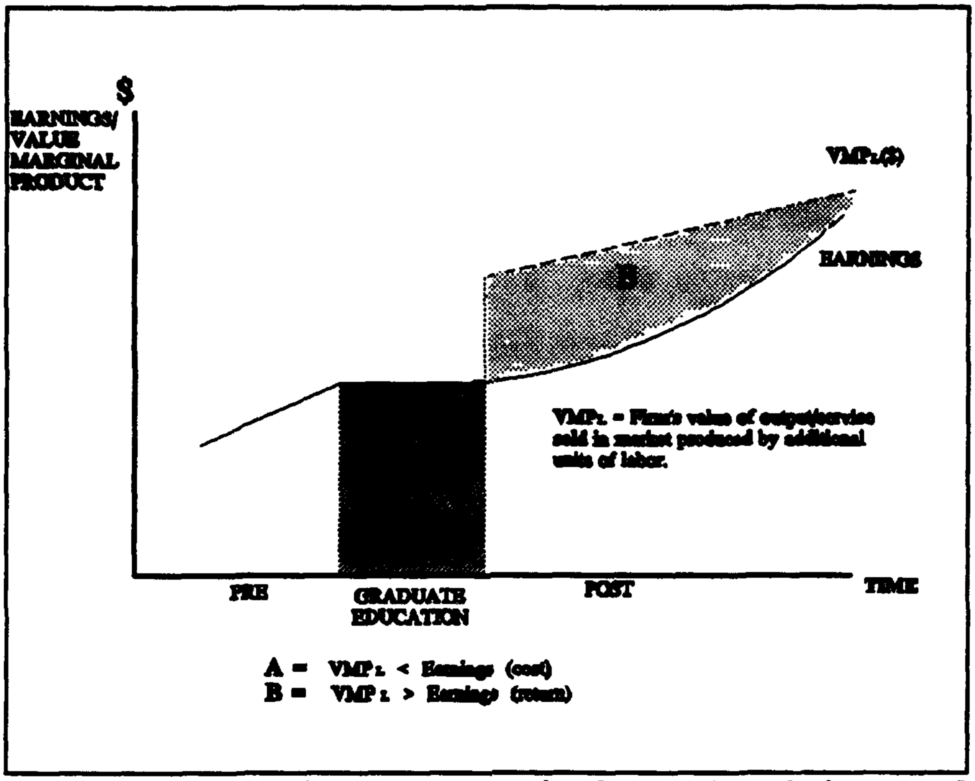

Figure 2. Value of Marginal Productivity and Earnings as related to graduate education.

marginal cost in terms of foregone productivity and direct outlays. [Ref. 6]

Individual officers pursue fully-funded graduate education in part because the monetary cost of the education is paid by the Navy, and in part because they anticipate greater returns in the future through enhanced promotion opportunities in the Navy and/or a more competitive position in the civilian job market at the end of their obligation. Although these are attractive benefits, the officer also incurs an opportunity cost; foregone knowledge, training, and additional qualifications that might be gained if he or she instead chose to remain within the warfare environment. Many officers fear the possibility of "falling behind" their peers while removed from the high-paced, competitive, operational warfare environment.

The third and final element of human capital investment theory central to this study is the timing of the investment. In theory, greater returns from human capital investments are realized the earlier the investment is undertaken. Providing graduate education early in an officer's career, assuming that he/she remains in the service for an extended period of time, affords the Navy a longer period of time to recover the investment. [Ref. 7] A condition of the fully-funded graduate education program is that officers serve a utilization tour within their subspecialty, attained through graduate education, no more than two years after graduation. This tour is called a "payback" due to its vital role played in recovering the Navy's investment. This requirement is difficult to enforce due to the highly structured time-sensitive URL career paths, especially within the Surface Warfare community. Consequently, the earlier the officer receives the subspecialty code, the more likely he or she will serve a utilization tour sometime in their career. On the other hand, learned knowledge of a specific specialty will depreciate over time if not applied. So, it is in both the

Navy's and the officer's best interest to serve a payback tour as soon as possible.[6]

B. RESEARCH ON PERSONNEL PROMOTION

The first study reviewed is D.J. Cymrot's, "Graduate Education and the Promotion of Officers," which attempted to assess the benefit to the Navy of providing graduate education to its officers in terms of its impact on promotion. Graduate education may provide an officer with technical or general information that better enables him to handle greater responsibilities commensurate with higher rank. If graduate-educated officers get promoted faster, and to higher ranks than other officers, this supports the contention that graduate education increases productivity within the organization. [Ref. 2]

Cymrot begins by deriving a formula to calculate the marginal benefit to the Navy of providing graduate education to officers. He identified three factors affecting the marginal benefit:

- the productivity of the base-case officer,
- the difference in the probability of promotion to the next rank in each year,

[6] See Bowman [Ref. 5] for a proposal to reduce graduate education human capital depreciation by separating the timing of the general education portion from the firm-specific portion of fully-funded graduate education in the Navy.

- the change in the productivity between ranks (i.e., associated with promotion).

The marginal benefit is the increase in productivity (or the marginal product of an officer) that results from graduate education. Cymrot assumes that productivity depends entirely on the officer's rank. The base-case officer is defined as an officer in the lowest rank (LT with 8 years of service). An index of productivity at each rank equals the ratio of the marginal product of a given rank to the marginal product of the base-case officer. [Ref. 2]

The data used in the analysis was an extract from the Officer Master File (OMF), comprising a historical cross section of all officers on duty in March 1985. The data was restricted to officers at certain lengths of service and ranks to avoid having the results affected by officers with atypical careers, such as enlisted personnel or warrant officers admitted to the officer corps, or staff officers who enter the service above the rank of Ensign.

The probabilities of promotion are obtained by a logistic model, since the dependent variable (promote, not promote) is limited to values of 1 or 0. Three types of explanatory variables are used in the promotion model: personal characteristics (graduate degree, age, sex, race); previous experience and performance indicators (time in rank, service continuity); and Navy structural variables (officer's community). Since promotability is one of the criteria used in determining whether an officer is allowed to obtain graduate education, potential selectivity bias exists due to the correlation between the dependent variable (promote) and assignment to the experimental group (graduate educated officers). Two variables, time-in-rank (capturing promotion rates) and service continuity (identifying breaks in service), are used by Cymrot in an attempt to control for potential observed selectivity bias. These two performance and experience variables are intended to account for some of the inherent differences in productivity associated with individual's selected for graduate education, which should be isolated from the measure of graduate education itself. [Ref. 2]

Cymrot examined four promotion points by creating subsamples by length of service (LOS) groupings for Lieutenant to Lieutenant Commander, Lieutenant Commander to Commander, Commander to Captain, and Captain to Flag. The impact of graduate education is positive and statistically significant in all groups except promotion to Flag officer. The fact that this result persisted even with the experience and performance indicators (time-in-rank, and service continuity) included in the model (to account for selection), supports the contention that graduate education does raise productivity by increasing the likelihood of promotion to the next higher rank. In fact, graduate education increased the probability of promotion to Lieutenant Commander by 26 percent, to Commander by 10.6

percent, and to Captain by 16.5 percent. It is interesting to note that promotion to Flag is conditional on previous promotion rates, all of which are positively related to having graduate education. Consequently, it is somewhat puzzling why graduate education is not significant in promotion to Flag. One reason might be if an officer is slow in getting promoted in the lower ranks, chances are, he/she never made it to Commander or Captain and since those up for Flag have already undergone a great deal of selection, they represent the best the Navy has and graduate education may seem unimportant by that time. [Ref. 2]

The time-in-rank performance variable consistently had negative and statistically significant coefficients, meaning that excessive time spent in previous ranks decreases the current probability of promotion. The positive and statistically significant effect of the service continuity experience variable conflicted with the hypothesis that a break in service would have a negative effect on productivity and would, thus, decrease the likelihood of promotion. This surprising result may be due to a large majority of those officers who leave and then reenter being above-average in terms of ability and performance.

Other significant factors in Cymrot's model were:

- age had a significantly positive impact on promotion, meaning older officers (possibly due to prior enlisted service) are more likely to promote than younger ones;

- unrestricted line officers were significantly more likely to promote than Staff or Restricted Line, but only for the Lieutenant to Lieutenant Commander LOS group; and

- length of service was significantly positive in all cases. [Ref. 2]

Cymrot then separated the sample by each successive length of service year in an attempt to determine whether graduate education leads to early promotion or whether it is only a guarantee of eventual promotion. Separate logit models were run on the probability of promotion for each year. The results are most striking at the eight year point, at which graduate education increases the probability of early promotion to Lieutenant Commander by nearly 60 percent. The effects for the remaining years are relatively small, concluding that graduate education ensures only eventual promotion after the eighth year of service. [Ref. 2]

In summary, Cymrot certainly established a positive relationship between promotion and graduate education. However, it is unlikely that he captured the "true" impact of graduate education on promotion. Since promotability is a criteria for graduate education selection, the presence of selectivity bias is probably much more of a potential problem than he had thought. The issue of *what* exactly makes these officers, selected for graduate education, more promotable must be addressed.

There were two ways in which Cymrot should have dealt with graduate education selection bias: (1) introduce previously excluded observed (measurable) factors as "proxies" to capture the selection process; and (2) utilize established statistical techniques to capture unobserved (unmeasurable) factors effecting selection. His attempt to account for inherent promotability with "proxies" to capture previous promotion rates (time-in-rank) and breaks in previous service is not adequate to fully explain graduate education selection. Promotability is not the only criteria used in selection; professional performance within rank, which may be captured through fitness reports, and academic experience are other factors that need to be addressed. When dealing with selection bias, it is necessary to account for all observed and unobserved factors contributing to selection into the "treatment group" (graduate educated officers). Cymrot failed to account for unobserved factors that contribute to selection bias. There are established statistical procedures that can be used to model the process of self-selection and to eliminate any biases caused by it.

A second study looked at promotion probabilities exclusively for Surface Warfare Officers. Joseph Nolan in his NPS Master's thesis, "An Analysis of Surface Warfare Officer Measures of Effectiveness as Related to Commissioning Source, Undergraduate Education, and Navy Training," developed multivariate models to estimate the determinants of three measures of effectiveness (MOE's) for Surface Warfare Officers (SWO): retention, promotion, and early professional qualifications. Performance differences by commissioning source and quality of undergraduate education are specifically highlighted. [Ref. 8]

An updated version of the Naval Officer Promotion History Data File, derived from the Navy Officer Master Files, and extracts from the Navy Officer Loss Files were obtained by Nolan from Dr. William Bowman of the U.S. Naval Academy. These files included background, experience, selection board results, and separation information for all officers reaching Lieutenant selection boards between fiscal years 1981 through 1985 and Lieutenant Commander selection boards between fiscal years 1985 through 1990. Navy training information was provided by the Naval Personnel Research and Development Center, San Diego, in its TRAINTRACK System Files. The final merged promotion data set was restricted to Surface Warfare Officers remaining within the community to the Lieutenant Commander selection board and to those obtaining a commission through USNA, ROTC, or OCS. [Ref. 8]

The independent variables used by Nolan to measure the likelihood of promotion to O-4 were grouped into four categories: (1) personal demographics (sex, race, dependents, age at commissioning, prior enlisted service, commissioning source); (2) undergraduate education (major, GPA, college selectivity, academic profile code); (3) Navy experience (service schools, duty stations, billets, additional qualifications, warfare designation); and (4) Navy training (academic setback, skill progression training, functional training). In the promotion model, the effects of Navy training are measured indirectly via a variable indicating attainment of early qualifications prior to the O-3 selection board. The goal was to determine whether a correlation existed between attainment of early qualifications and promotion to O-4. The sample is further broken down by quality of undergraduate college (low, medium, and high) to determine differences in promotion probabilities based on college academic rank. Rankings were obtained from Barron's Profiles of American Colleges. [Ref. 8]

The promotion model was estimated for a pooled sample consisting of all commissioning sources and college selectivity levels and then separately by commissioning source and by college selectivity level. The results were as follows:

(a) Significant <u>positive</u> effects on promotion to O-4 were obtained for the following variables: early professional qualifications, high GPA, high technical qualification code (TQC), Engineering Officer of the Watch qualified, Tactical Action Officer qualified, Department Head School graduate, served in a combat systems officer department head billet, and served as operations officer (NTDS) department head.

(b) Significant <u>negative</u> effects were obtained for being single, age at commissioning, and being male. It should be noted however, that males constituted 98 percent of the sample, reducing the reliability of the sex variable.

(c) Of the variables with the largest positive impact, Department Head School graduates were 28 percent more likely to promote, Combat Systems Officers 7 percent more likely, Operations Officers (NTDS) 10 percent more likely, and those with Tactical Action Officer qualification 8 percent more likely.

(d) Variables with negative impacts revealed that males were 20 percent less likely to promote, minorities, although insignificant, were 4 percent less likely to promote than whites, and there was no significant difference between commissioning source and school selectivity. [Ref. 8]

In the three promotion model specifications divided by low, medium, and high college quality, graduation from Department Head School was the only variable significantly positive across all three categories. Commissioning source is significant only in the highly selective category, where ROTC reveals a negative impact on promotion to O-4. Significant positive effects from early qualifications is present in both the high and medium selectivity groups. Department head billet type was significant only in the medium selective category. In the low-college quality category, only

Department Head School graduate was positively significant in predicting promotion to O-4. [Ref. 8]

Two other measures of effectiveness, early professional qualification, and retention, were also estimated using nonlinear logit models. Early professional qualification indicated whether or not an officer earned Additional Qualification Designators (AQD's) as a Surface Warfare Officer, Engineering Officer of the Watch, or Officer of the Deck (underway). The results indicate the following: officers with just one dependent were 28 percent more likely to attain early qualifications compared to single officers; OCS and ROTC graduates were 5 percent and .1 percent less likely to attain early professional qualifications compared to USNA graduates, respectively; white officers were 7 percent more likely than minorities to attain early qualifications; officers with more than one sea tour were 13 percent more likely than those with just one sea tour; officers with an academic setback or dropout from a Navy school were 9 percent less likely than those without; and an officer with more functional or skill progression training days is more likely to attain early qualifications than one with less days. In the model specifications divided by college quality, functional training days was the only variable significant across all three groups, and had a positive impact. [Ref. 8]

Retention was defined as whether or not an officer remained in the service up to the O-4 promotion board.

Explanatory variables including high GPA, high TQC, technical major, and age at commissioning all had significant positive effects on retention. Variables with significant negative effects included white, OCS graduate, ROTC graduate, high quality college, academic setback/attrition, and prior enlisted service. When analyzed by college quality, only two variables were significant across all three categories. Age at commissioning had a significant positive effect on retention and ROTC graduate was negative when compared to USNA in the high quality category, positive when compared to OCS in the medium, and negative compared to OCS in the low category. [Ref. 8]

It can be concluded from these results that background factors play a significant role in explaining MOE attainment. Given the significance of training investments for graduates of medium and low-quality colleges in their MOE attainment, future budget cuts in Navy training will affect these two groups the most.

In light of significant differences in promotion probabilities in the pooled model, there are important policy implications to be gained from Nolan's results. The results seem to support the hypothesis that promotion to O-4 is highly dependent on attainment of Department Head school and key qualifications. Although multivariate analysis of promotion across college quality failed to reveal much, bivariate analysis determined that OCS commissioned officers in the high college quality category had promotion rates 6 and 12 percentage points higher than the medium and low quality categories, respectively. The significance of the early professional qualifications variable may be valuable in formulating future force downsizing policies in that it provides a measure of effectiveness at the three year point in predicting selection to the career force. [Ref. 8]

C. RESEARCH ON OFFICER FITREPS

The report on the fitness of officers (FITREP) is the major document used for periodic internal evaluation of the performance of naval officers. FITREPs provide information to the Navy that is important for promotion, billet assignment, and retention. [Ref. 9] FITREPs also provide information on performance within rank, which is one of the criteria used in measuring an individuals productivity within the military.

Most Commanding Officers (CO's) complete FITREPS with two purposes in mind: promotion potential, and command-related selection decisions. However, CO's have expressed a conflict between their obligation to identify average (or less than average) performers and their obligation to write FITREPS that will not destroy an officer's chance for promotion. Consequently, most junior officers tend to be ranked in the top 1 percent regardless if they deserve to be there or not. This quandary is commonly referred to as "grade inflation." The recurring problems of grade inflation, also referred to as the "halo effect," have led to questions of usefulness of FITREPs in selecting officers for promotion and assignment. However, there are a few elements on FITREPs with sufficient variability to support the belief of selection boards that the FITREP is an adequate indicator of an officer's promotability and potential for command. [Ref. 9]

A study by Idell Neumann of the Navy Personnel Research and Development Center (NPRDC), San Diego, developed a performance index derived from officer fitness reports. The index was to be used to expand the scope of the Naval Academy selection system by including predictions of officer performance in the fleet after graduation. Her goal was to establish a relationship among existing admission criteria with the performance index and then develop predictors of officer performance for applicants to be used as part of the selection criteria. [Ref. 10]

The data for the development of the performance index consisted of all Naval Academy graduates from 1979 through 1982 in the Surface, Submarine, and Air warfare communities. These specific year groups were chosen because these officers had (at that time) at least 4 years of commissioned service with officer fitness records, available USNA admission information and performance scores, and response data for criteria used in the USNA admission program. Including several year groups also helped to account for possible differences across USNA graduating classes. The data set for the analysis consisted of background information provided by the Naval Academy, which was merged with officer fitness report information available from NPRDC files. [Ref. 10]

In order to maintain consistency across all fitness reports, FITREPs were included for pay grades O-1 to O-3 based on the following criteria: (1) if based on "close" observation by the reporting senior; and (2) if the officer was simultaneously rated with other officers in his/her command (either a "periodic" or "detachment of reporting senior" occasion). Neumann selected three possible rating elements within the fitness reports that would encompass the officer's overall performance on each FITREP:

1. Command Desirability: the reporting senior's rating of the desirability of an officer being under his/her command in a command assignment;

2. Mission Contribution: the evaluation of the officer's contribution to the unit's mission; and

3. Recommendation for Promotion: the reporting senior's recommendation of the individual for either early, regular, or no promotion. [Ref. 10]

The distributions of the three rating elements illustrated the difficulties associated with "grade inflation." The elements were highly skewed to the upper end of the evaluation scale; consequently, a summary score was used, which computed the proportion of occasions on which the officer received the highest possible rating on all qualified fitness reports for each element was used. An element summary score of 1.0 indicated that the officer received the highest rating on all

FITREPs in the particular element, while a score of 0.0 indicated never receiving a top rating. Further evaluation revealed that "recommended for early promotion" (REP) was the only element with sufficient variability to be used as a performance index. Only 26 percent received "recommended for early promotion" over their entire fitness report file, while over 58 and 61 percent of the individuals received top ratings over their entire FITREP file in Command Desirability and Mission Contribution, respectively. [Ref. 10]

Neumann further discovered significant differences in the mean value of the performance index between pay grades, warfare specialties, and year groups, preventing the use of a pooled sample with raw performance index scores. Since the greatest difference was between grades, three separate performance index scores were computed for each pay grade (ENS, LTJG, and LT). The three scores were then weighted according to the number of FITREPs for each rank and summed to generate one performance index score reflecting an officer's complete fitness report history. [Ref. 10]

The results of Neumann's analysis, obtained by utilizing ordinary least squares multivariate statistical techniques, are somewhat surprising. Out of all the factors used in admission criteria for the Naval Academy, only two non-academic predictors had a significant positive association with REP. High school recommendations and extracurricular activities proved to be the best predictors of officer performance potential, while academic criteria (i.e., SAT score, and high school class rank) seemed to be unrelated. However, it should be noted that those admitted to the Academy are selected based upon superior academic performance. [Ref. 10]

A second officer performance index was developed by William R. Bowman of the U.S. Naval Academy in his article, "Do Engineers Make Better Naval Officers?" Bowman attempted to test the hypothesis that the best naval officers are those with a solid technical college background (e.g., those who major in engineering or math and science). This was labeled the "Rickover hypothesis." In contrast to Neumann's performance index, Bowman uses only one fitness report to measure performance, the last report received as a Division Officer (i.e., near the end of the fourth year of active duty). This FITREP was thought to provide the best indication of potential future performance. [Ref. 11]

The objective was to model the statistical relationship between an individual's academic major and performance at the Naval Academy and his performance later as a junior officer in the fleet. Bowman analyzed male Naval Academy graduates from 1976 through 1980, but restricted the sample to those who entered the surface and submarine warfare communities on the premise that these two communities are the most technically oriented and would benefit most from technical degrees. The data set was constructed by merging academic information contained in the Academy's registration files, fleet experience information contained in the 1986 Navy Officer Master/Loss file from the Defense Manpower Data Center, Monterey, and a longitudinal profile of officer fitness reports from the Navy Personnel Research Development Center, San Diego. [Ref. 11]

Bowman utilized two measures of junior officer performance as dependent variables in his multivariate regression models to determine which graduates (technical, or non-technical) are: (a) more likely to achieve "superior performance"; and (b) more likely to remain in service at least six months beyond initial period of obligation. [Ref. 11]

In the development of his FITREP-based performance index, Bowman selected a single FITREP that indicated "frequent" contact with the reporting senior officer, that evaluated the officer in relation to his peers (i.e., periodic/annual, or on the occasion of detachment of a reporting senior officer), and was the last report as a Division Officer. A "superior performer" was defined as one who was recommended for early promotion, and ranked in the top 1 percent category both for "command desirability" and in the "overall summary" evaluation on the selected FITREP. As was the case in Neumann's study, Bowman found that "more discriminating criteria for officer superiority are not available for junior naval officers." [Ref. 11]

Prior to estimating the performance model, Bowman recognized potential selection bias due to two types of selection behavior that may indirectly affect officer performance and retention, since they occur prior to entry into the fleet. The first is the screening process into the nuclear surface/submarine communities. Training for the nuclear power community is highly technical so that those majoring in technical areas or others who perform above average in technical courses are more likely to be selected into the program. The second is the self-selection process whereby the officer chooses one warfare community over another.

Self-selection bias may exist if unobservable factors, such as desire, motivation, or attitude, affect the selection of one community over another and if the unobservable factors, in turn, have an impact on fleet performance and retention. Given that nearly 90 percent of all graduates in nuclear power communities have technical majors and grade point averages (GPA) above 2.5 (compared to only about 50 percent in conventional surface), failure to account for unobserved factors that may help to explain this difference could bias the evaluation of the relationship between academic major and fleet performance and retention. [Ref. 11]

Bowman attempted to test/control for self-selectivity bias through the use of the Heckman procedure,[7] which accounts for unobserved factors retained from the selection equation through a new independent variable which is placed in the main performance equation. This variable, commonly called the inverse Mills ratio (or LAMBDA), was found to be statistically insignificant, meaning that selectivity bias was not detected. Although the warfare community selection model provided significant evidence that technical majors with higher GPA's are more likely to choose and be selected for nuclear programs, Bowman attributed LAMBDA's insignificance to the lack of correlation between the error structures of the two equations. [Ref. 11]

Bowman's main performance model analyzed a binary dependent variable for "superior" performance, which was set=1 for a superior performer and set=0 otherwise. The model was estimated using a nonlinear logit technique. The first category of explanatory variables included binary variables for ship type, warfare qualifications, fitness report parameters, and other variables for personal demographics. The second category of explanatory variables were the focus of the study -- dummy variables for academic major, and a continuous variable for grade point average. Some notable results include the following. Serving on aircraft carriers,

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[7] See Heckman [Ref. 12] for further discussion on the technique used to control for potential selection bias.

relative to destroyers and ballistic missile submarines, increased the probability of achieving superior junior officer performance by 33.6 and 69.7 percent in the conventional and nuclear navies, respectively. Achieving a warfare qualification increased superior performance by 14.2 percent in the nuclear Navy, and 35.1 percent in the conventional. Racial minorities were from 19.2 percent to 25.6 percent less likely than whites to achieve superior performance. [Ref. 11]

Bowman's retention model also analyzed a binary dependent vari[illegible] that indicated whether or not an officer stayed at least six months beyond initial obligation. Some notable results include the following. Nuclear officers serving on cruisers and attack submarines (relative to nuclear ballistic submarines) were 21.1 percent and 13.9 percent more likely to stay, respectively. Occupation relative to an engineering-maintenance billet seemed to have the largest effect on the nuclear Navy, where officers filling an administrative billet were 42.6 percent more likely to stay. Other factors having significant positive impacts on retention included attaining a warfare qualification and being black in the conventional Navy. Being married (with or without children) had a significant negative impact on retention in both conventional and nuclear navies. [Ref. 11]

Bowman's analysis of the academic factors found few significant relationships to junior officer performance and retention. Bowman contends that the Rickover hypothesis cannot be supported because: (a) technical major is statistically insignificant in the superior performance model, and (b) management/economics majors are 24.1 percent more likely to attain a superior performance rating relative to engineering majors in the conventional surface Navy. This could mean that junior officer performance is more dependent on managerial skills than technical knowledge, a far cry from Rickover's belief. [Ref. 11]

D. SELECTIVITY BIAS

An article written by Burt S. Barnow, Glen G. Cain, and Arthur S. Goldberger, entitled "Issues in the Analysis of Selectivity Bias," indicates that selectivity bias is a potential problem whenever there exists unmeasured (unobservable) factors related to an explanatory variable that helps explain both the selection behavior into a "treatment" (or control) group and the program outcome under study. The term "bias" refers to the potential that the estimated impact of the explanatory variable defining the treatment (control) group on the outcome of the main dependent variable is not equal to the "true" impact. If assignment to the treatment group is random, then selectivity bias is <u>not</u> an issue, since there are no factors (observed or unobserved) that differentiate selection behavior. However, selectivity bias continues to affect most econometric models since assignment of observations to treatment and comparison groups is seldom explicitly random especially in non-experimental data. [Ref. 13]

The selectivity issue relevant to this thesis deals with selection into the Navy's fully-funded graduate education program. Navy graduate education policy makers base selection for FFGE on academic capability, outstanding professional performance, promotion potential and a strong educational background. [Ref. 3] This suggests that selection is indeed not random and one must be able to predict selection to the Navy's graduate education program to adjust for the potential bias created by the Navy's selection process (and self-selection by individuals). There are certain observed factors that explain this selection process, but there are also significant unobserved factors that may affect both assignment to the treatment group and the outcome measure. For instance, outstanding (pre-graduate education) professional performance and promotion potential may be explained by unmeasurable factors such as an individual's self-drive, motivation, and desire for achievement. There are established econometric procedures designed to capture estimates of unobserved factors, but the success of such procedures is dependent upon correct specification of the selection model.

One common way to attack selectivity bias is to simply include a number of "proxy" variables in the outcome equation thought to account for the (observed) selection behavior or process. This is the approach used by Cymrot in the study cited above [Ref. 2]. This approach assumes that there are no other variables, beyond those included as proxies, that are related to the outcome. Obviously, there are flaws associated with this approach. Specifically, if explanatory variables related to selection, but not to the outcome are omitted, the bias problem still exists. [Ref. 13]

A second approach is a two-stage procedure based on work done by James J. Heckman [Ref. 12], commonly called the Heckman procedure. This technique is outlined in a study completed for the Department of Labor [Ref. 14]. In the first stage, selection into the treatment and comparison groups is modeled through a nonlinear probit analysis using at least one determinant that has no effect on the main outcome equation. The reason for using a different variable in the selection equation is to ensure "identification" of the model.[8] In addition to estimates of the coefficients in the selection model, the probit provides an estimate of a correction factor, LAMBDA (λ), which encompasses values for unobserved factors obtained from the error structure of the selection model based on the probability of the likelihood of acquiring the treatment for each observation. In the second stage, the estimated LAMBDA is included as a regressor in the main outcome equation along with the treatment variable and other

[8] Identification is a precondition where at least one of the predetermined variables, from the selection equation, is omitted from the main equation to differentiate between the specifications of the two equations. [Ref. 16]

factors related to the outcome. The typical procedure specifies that the outcome equation be estimated in a linear fashion using ordinary least squares in order to maintain consistent estimates; however, this thesis uses nonlinear logit models for two of the three outcome equations due to the binary nature of the dependent variables.[9] The Heckman two-stage procedure expressed mathematically is as follows [Ref. 14]:

Stage 1:

The selection probit is defined as:

$$Pr(z=1)=Pr(w>-v'\gamma)=\frac{\Phi(v'\gamma)}{\sigma}$$

where: z is the (0,1) comparison/treatment group indicator,
w is a normal random variable,
$v'\gamma$ are the estimates of a vector of observed characteristics that influence selection,
σ is the standard deviation of z,
Φ is the unit-normal cumulative distribution function.

A correction factor, λ, is then formed for each observation:

for a treatment group member,

$$\lambda=\frac{\phi(H)}{(\Phi(H))};$$

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[9] Although two-stage selection procedures generally specify a linear ordinary least squares model to be used in the second stage, William H. Greene in his LIMDEP Version 6.0 User's Manual and Reference Guide, makes reference to a two-step procedure that supports the use of nonlinear regression techniques in both steps. [Ref.15, p.637]

and for comparison group members,

$$\lambda = \frac{-\phi(H)}{(1-\Phi(H))};$$

where: $\phi(\cdot)$ is the normal density function;

and

$$H = \frac{(v'\gamma)}{\sigma}.$$

<u>Stage 2</u>:

The estimated value of the correction factor, λ', is included as a regressor in the outcome equation:

$$y_i = \beta_0 + \chi_i'\beta_1 + \gamma z_i + \delta\lambda_i' + \mu_i$$

where: y_i = outcome measure for individual i;
x'_i = vector of explanatory variables;
z_i = indicator of selection status;
λ'_i = estimated values of the correction factor; and
μ_i = individual random error term.

By modeling selection with this two-stage process, the objective is to specify a multiple regression that "holds constant" those characteristics not already in the model that affect the outcome and are correlated with selection into the treatment group. [Ref. 14]

There are potential weaknesses associated with the Heckman procedure that may limit its effectiveness. The probit analysis of the selection model may not yield accurate predictions if it is not correctly specified. If the selection process is not explained well, the first stage produces an unreliable estimate of the correction factor (LAMBDA). Hence, including LAMBDA in the second stage may lead to ambiguous estimates of the effect of the treatment. If the treatment estimate seems unreasonably large, for example, one should check for excessive correlation (multicollinearity) between LAMBDA and other variables in the second stage. Another limitation that may pose difficulties with this procedure is the existence of other types or levels of selection that precede the one in question. Such a sequential selection process would require the use of an ordered probit analysis, or multiple selection rules. Essentially, the Heckman procedure depends heavily on its ability to predict treatment/comparison group status. [Ref. 14]

Finally, another concern with selectivity bias arises when being in a treatment group determines the outcome. For example, the fact that an officer has attained fully-funded graduate education may cause promotion to the next higher rank. This causality is referred to as endogeneity, which violates the econometric assumption that the error term and each explanatory variable are independent of each other. [Ref. 16] A procedure developed by Burt S. Barnow et al. corrects for this biased endogenous relationship using a two-stage process very similar to Heckman's. Barnow's first stage is identical to that of Heckman's, in which a probit analysis predicts selection into the endogenous treatment group and probabilities of selection associated with each observation. The second stage, instead of using LAMBDA, uses the predicted probabilities as an "instrument variable" in place of the treatment explanatory variable in the outcome equation. The use of this new instrument variable removes the endogeneity as well as the correlation with the error term. [Ref. 13]

III. DATA AND METHODOLOGY

This chapter discusses the officer data base and how it was used to develop explanatory variables related to the three measures of performance introduced in Chapter I. A discussion of the statistical methodologies used in obtaining the empirical results concludes the chapter.

A. DATA

Two data sets were used in this analysis. The first was obtained from Dr. William R. Bowman of the U.S. Naval Academy. Using information from the Navy Officer Master File, maintained at the Defense Manpower Data Center (DMDC), Monterey, CA, he created an updated version of the Navy Officer Promotion History Data File. Bowman's data provided the means to create two separate files containing background, Navy experience, and promotion selection board results for all officers going before the Lieutenant (LT/O-3) selection board between fiscal years 1981 and 1985 and the Lieutenant Commander (LCDR/O-4) selection board between fiscal years 1985 and 1990. Merging these two files determined which officers remained in the Navy at least until the LCDR selection board.

Since the focus of this thesis is on Surface Warfare officers, the officer community designator was used to restrict the sample to the Surface Warfare community. Only the SWO's who remained in the service through the LCDR promotion board and who stayed in the community were retained in the final sample. Officers transferring into the SWO community were included since it is generally done early in one's career. A total of 1,860 SWOs were extracted from Bowman's data files. However, 282 observations were lost due to missing values when creating variables, leaving 1,577 observations for the final sample.

The second data set used is a longitudinal profile of officer fitness reports, obtained from the Navy Personnel Research and Development Center (NPRDC), San Diego, CA. Matching social security numbers from Bowman's data set to the FITREP files provided a complete history of FITREPs for each officer reaching the LCDR promotion point. Although this study is restricted to Surface Warfare officers, FITREP file histories were obtained for all officers to facilitate future research efforts on other URL communities.

The FITREPs selected for inclusion in the analysis were restricted to those that indicated "periodic" or "detachment of reporting senior" in the block for occasion, "regular" in the block for type of report, and "close" in the block for basis of the reporting senior's observation of the officer. These restrictions ensured that officers in the sample were evaluated against all their peers in the command, and that they worked closely with the Commanding Officer, which reveals a more accurate picture of the officer's true performance.

Not observed (NOB) reports, submitted for short periods of duty or during schooling, fail to provide any meaningful performance information. Consequently, they were omitted from the sample. The data element "early," containing the recommendation for promotion, was used as the indicator of an observed report since it is left blank on all NOB reports. The final restriction on FITREPs was on the period of the report. Since Bowman's data was limited through fiscal year 1990, FITREPs submitted covering a period extending beyond 1990 were omitted.

Fitness report files for each officer were subdivided into two categories according to rank, labelled as "early" and "late." Early FITREPs included those obtained as an Ensign (O-1) or Lieutenant Junior Grade (O-2), and late included those obtained as a Lieutenant (O-3). The reason for this division is twofold. First, since early FITREPs evaluate the majority of the officer's initial obligation, it is of interest to determine the effect of early performance on post-initial obligation performance. Second, given that most officers obtain graduate education during their first shore tour, normally at 5 to 6 years of service, most of the late (LT) FITREPs are received after the attainment of graduate education. This allows one to determine performance differences before and after graduate education.

The subsample of SWO's (N=1,577), created from Bowman's promotion history data files, and the sample of FITREP files were merged by assigned ID numbers, keeping only those officers containing information in both files. This merge found 100 officers with incomplete FITREP files, thus yielding a final working sample of 1,477 SWO officers.

Figure 3 displays the seven categories of explanatory variables used in the statistical models of selection, promotion, percent of LT FITREPS recommended for early promotion, and last LT FITREP RAP. Although not all the variables are used in every model, it is important to understand the process by which each was created. Table I, presented at the end of this section, specifically defines the coding for each explanatory variable.

The FITREP performance variables were created based on a performance index developed by Idell Nuemann at NPRDC. Separate summary scores were calculated for FITREPs defined as early (EPCTREP) and late (LPCTREP) by obtaining the proportion of all early and late FITREPS recommended for early promotion, yielding two continuous variables. As with Neumann's study, distributions of FITREP rating elements established "recommendation for early promotion" as the single most

FITREP PERFORMANCE
EPCTREP - PERCENT OF EARLY RAPS
LPCTREP - PERCENT OF LATE RAPS

COMMISSIONING SOURCE
HISLROTC - ATTENDED HIGH SELECT ROTC COLLEGE
HISLOCS - ATTENDED HIGH SELECT COLLEGE THEN OCS
LOSLROTC - ATTENDED LOW SELECT ROTC COLLEGE
LOSELOCS - ATTENDED LOW SELECT COLLEGE THEN OCS
USNA - ATTENDED NAVAL ACADEMY
NESEP - ENLISTED COMMISSION PROGRAM

PERSONAL DEMOGRAPHICS
SEX - MALE OR FEMALE
MINORITY - NON-CAUCASION
AGENOW - CURRENT AGE
MARONLY - MARRIED NO CHILDREN
MARCHILD - MARRIED WITH CHILDREN
DIVCHILD - DIVORCED WITH CHILDREN
SINGLE - NOT MARRIED

NAVY EXPERIENCE
NUC - NUCLEAR POWER OFFICER
NOCOMBAT - NEVER SERVED ON A CRUDES SHIP
NODEPHD - NOT YET ATTENDED DEPARTMENT HEAD SCH
EOOWQUAL - ENGINEERING OFFICER OF THE WATCH QUALED
TAOQUAL - TACTICAL ACTION OFFICER QUALED
EARSWO - ACHIEVED SURFACE WARFARE QUAL BEFORE LT BOARD
EAREOOW - ACHIEVED ENGINEERING OFFICER QUAL BEFORE LT
EARTAO - ACHIEVED TACTICAL ACTION OFFICER QUAL BEFORE LT

ACADEMIC PROFILE
GPA - UNDERGRAD GRADE POINT AVG
MATHSKIL - UNDERGRAD MATH EXP
TECHSKIL - UNDERGRAD SCIENCE EXP
ELIGCURR - NUMBER OF CURRICULA ELIGIBLE AT NPS

FISCAL YEAR OF O-4 SEL BD
FY1985 - FY1990

TREATMENT VARIABLE
FFGE - ATTAINED FULLY-FUNDED GRADUATE EDUCATION

Figure 3. A list of explanatory variables grouped by category.

discriminating factor in the rating of officers.[10]

Commissioning Source and undergraduate college academic rank, obtained from Barron's Profiles of American Colleges, were combined to determine if performance differences could be attributed to the undergraduate school's quality. Highly

[10] The data revealed that only 49 percent of all SWO FITREPs were "recommended for early promotion", while 70 and 67 percent of all SWO FITREPs received the highest possible grades in "command desirability" and "mission contribution", respectively. Remaining FITREP elements revealed even greater skewness toward the upper end of the grading scale.

selective undergraduate colleges were defined as those with "most," "highly," and "very competitive" rankings in Barron's Profiles. Schools with lower rankings in Barron's were defined as having low competitiveness. As displayed in Table I, undergraduate college quality criteria were applied only to officers from Reserve Officer Training Contract/Scholarship (HISLROTC, LOSLROTC) and Officer Candidate School (HISELOCS, LOSELOCS), since the majority of the officers in the sample are commissioned through the highly competitive Naval Academy (USNA). The six possible commissioning source variables are binary in nature, and measured on the positive condition (commission source=1, else=0).

The personal demographic variables include seven individual characteristics that may effect performance. The sex of the officer is coded as a binary variable, with (FEMALE=1, else=0). Minority is also a binary variable (MINORITY), defined with race/ethnic codes indicating black or other than white (black/other=1, else=0). The current age of the officer is used as a continuous variable (AGENOW), indicating the exact age of the officer at the time of his or her O-4 selection board. Four additional binary variables are used to combine marital status and dependent information, indicating married with children (MARCHILD), married without children (MARONLY), divorced with children (DIVCHILD), or single with no dependents (SINGLE).

Variables indicating specific Navy experience were selected based on certain qualifications and credentials considered vital early in a Surface Warfare officer's career. All eight experience variables are binary, indicating whether or not the officer possesses a particular qualification or credential.

Nuclear power designated officers were identified through the Additional Qualification Designator (AQD) data element. Since nuclear officers are required to obtain their engineering qualification first, well before consideration for the O-4 promotion board, any officer with an AQD in nuclear power engineering were designated as a "NUC."

Combatants (CRUDES ships), including cruisers, destroyers, frigates, and battleships,[11] are considered the "backbone" of the surface fleet. Serving on one of these ship types is considered career-enhancing for SWOs due to the emphasis placed on weapon systems and the fact that all the Commanding Officers are designated Surface Warfare Officers. A data element revealing duty stations was used to count the number of CRUDES ships an officer had served on. The created variable (NOCOMBAT) indicated that an officer had <u>never</u> served on a CRUDES ship.

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[11] Currently, there are no battleships in active service. During the period this data was gathered (Fiscal Years 1981-1990), all four Iowa class battleships were in commissioned service.

Attending SWO Department Head School as early as possible after completion of the first sea tour is essential in the SWO career path. Surface program managers contend that completing Department Head School by the seventh year of service is vital within the designed SWO time-line to meet designated career goals. Since promotion to O-4 generally occurs in the eighth to ninth year of service, completion of Department Head School before the selection board is crucial. A data element indicating service schools attended was used to identify whether or not an officer had completed the Department Head course. The created variable (NODEPHD) signifies that an officer has not yet attended Department Head School.

There are three essential qualifications that a SWO must obtain: (1) qualification as a Surface Warfare Officer (SWOQUAL); (2) Engineering Officer of the Watch (EOOWQUAL); and (3) Tactical Action Officer (TAOQUAL). Using the AQD data element, two sets of variables identifying qualifications in these three areas were created: (1) whether or not the officer had attained EOOW or TAO prior to the O-4 board; and, (2) whether or not the officer had achieved an early SWO, EOOW, or TAO qualification prior to the O-3 board. SWO qualification after the O-3 board was not included in the analysis, since it is required during the first sea tour and nearly all the officers in the sample had acquired it by then.

Criteria for graduate education selection is contained in the academic profile variables. Three continuous variables from Bowman's data are used to indicate undergraduate education experience and performance:

1. Undergraduate Grade Point Average (GPA) is assigned values ranging from 0 to 5, 0 being the lowest and 5 the highest;

2. Math Qualification Code (MQC) is assigned values ranging from 0 to 6 in ascending order of calculus difficulty and performance;

3. Technical Qualification Code (TQC) is assigned values ranging from 0 to 5 in ascending order of physics difficulty and performance.

An additional continuous variable utilizes these three academic profile codes to determine the number of Naval Postgraduate School (NPS) curricula one is eligible for (ELIGCURR). Criteria for this measure was obtained from the Naval Postgraduate School Catalogue of courses for 1993. [Ref. 1] Surface Warfare officers are eligible for 29 out of a total of 38 available curricula and the values for this variable range from 0 to 29.

Department of the Navy officer manning requirements change from year to year. Consequently, a variable indicating the fiscal year of each officer's selection board (FYSB85-FYSB90) was used to control for potential differences in promotion opportunity across different year groups.

Officers with fully-funded graduate educations comprise the "control (or treatment) group" since they are the focus of this study and are compared to the remaining officers in the sample without this "treatment." The data element used to create this treatment variable (FFGE) included four conditions: (1) NPS graduate degree, (2) fully-funded civilian school graduate degree, (3) non-funded graduate degree, or (4) no graduate degree. Combining the first two possibilities defined the group of officers with fully-funded graduate education.[12]

Table I provides a complete description of the definitions of the explanatory variables used in the analysis below. The next section of this chapter describes the dependent measures and the specifications of the models to be estimated.

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[12] The data discriminates only between fully-funded and non-funded graduate educated officers, and since non-funded graduate educations are obtained at no cost to the Navy, it was decided to restrict the treatment group to fully-funded graduate educated officers.

TABLE I. DESCRIPTION OF EXPLANATORY VARIABLES.

VARIABLE	DESCRIPTION
FITREP PERFORMANCE	
EPCTREP	= percent of all ENS and LTJG FITREPS "recommended for early promotion"
LPCTREP	= percent of all LT FITREPS "recommended for early promotion"
COMMISSIONING SOURCE	
HISLROTC	= 1 if commissioned through ROTC at a "most", "highly", or "very" competitive undergraduate school = 0 otherwise
HISELOCS	= 1 if commissioned through OCS and attended a "most", "highly", or "very" competitive undergraduate school = 0 otherwise
LOSLROTC	= 1 if commissioned through ROTC at an undergraduate school not ranked above competitive = 0 otherwise
LOSELOCS	= 1 if commissioned through OCS and attended an undergraduate school not ranked above competitive = 0 otherwise
USNA	= 1 if commissioned at the U.S. Naval Academy = 0 otherwise
NESEP	= 1 if commissioned by the Naval Enlisted Service Education Program through OCS = 0 otherwise
PERSONAL DEMOGRAPHICS	
SEX	= 1 if female
MINORITY	= 1 if black or other than white
AGENOW	= age at time of O-4 selection board
MARONLY	= 1 if married and no children
MARCHILD	= 1 if married with children
DIVCHILD	= 1 if divorced/separated with child
SINGLE	= 1 if never been married or divorced and no children
NAVY EXPERIENCE	
NUC	= 1 if designated Nuclear Power
NOCOMBAT	= 1 if never served on a combatant/CRUDES ship

VARIABLE	DESCRIPTION
NODEPHD	= 1 if not yet attended Department Head School
EOOWQUAL	= 1 if Engineering Officer of the Watch qualified
TAOQUAL	= 1 if qualified as Tactical Action Officer
EARSWO	= 1 if achieved early Surface Warfare Officer qualification, before the O-3 promotion board
EAREOOW	= 1 if achieved early Engineering Officer of the Watch qualification, before the O-3 promotion board
EARTAO	= 1 if achieved early qualification as Tactical Action Officer
ACADEMIC PROFILE	
GPA	undergraduate grade point average where; 0=0-1.89, 1=1.9-2.19, 2=2.2-2.59, 3=2.6-3.19, 4=3.2-3.59, 5=3.6-4.0
MATHSKILL	where 0=no math, 1=pre-calc, 2=two pre-calc with B avg, 3=calc with C avg, 4=two calc with C+ avg, 5=two calc with B+ avg, 6=sig post-calc with B+ avg
TECHSKILL	where 0=no physics, 1=physics with C avg, 2=physics sequence with C+ avg, 3=phys seq with B+ avg, 4=eng/phys major with C+ avg, 5=eng/phys maj with B+ avg
ELIGCURR	= number of NPS curricula eligible, ranging from 0 to 29
FY OF O-4 SEL BOARD	
FYSB85	= 1 if O-4 selection board was in fiscal year 1985
FYSB86	= 1 if O-4 selection board was in fiscal year 1986
FYSB87	= 1 if O-4 selection board was in fiscal year 1987
FYSB88	= 1 if O-4 selection board was in fiscal year 1988
FYSB89	= 1 if O-4 selection board was in fiscal year 1989
FYSB90	= 1 if O-4 selection board was in fiscal year 1990
TREATMENT VARIABLE	
FFGE	= 1 if has fully-funded graduate education degree from NPS or Navy sponsored civilian institution

B. METHODOLOGY

The purpose of this thesis is to determine the impact of fully-funded graduate education on three measures of performance: (1) promotion to O-4 (yes-no), (2) percent RAP of LT FITREPs, and (3) RAP of last LT FITREP prior to the O-4 board (yes-no). Because selection for FFGE is based on established criteria, it is not the result of a random process. As discussed in the literature review in Chapter II, non-random selection into any treatment introduces the potential for bias when attempting to estimate the effects of being in the treatment group. Thus, it is imperative to be able to predict FFGE selection with sufficient accuracy to obtain reliable correction factors to control for selection bias in the performance models.

Selection for fully-funded graduate education and the three measures of performance are the dependent variables of the four main statistical models specified and estimated in this study. Table II provides a complete description of the definitions of the dependent variables used in the models.

For each performance measure, four different model specifications are estimated. These are designed to demonstrate the marginal effect of FFGE on performance where different controls are introduced. The first specification measures the marginal effect of fully-funded graduate education with no controls; the second specification measures this effect with observed control factors included in the equation. The third and fourth specifications apply two alternative techniques to correct for the presence of selectivity bias.

TABLE II. DESCRIPTION OF DEPENDENT VARIABLES.

VARIABLE	*DESCRIPTION*
SELECTION MODEL	
FFGE	*= 1 if has fully-funded graduate education degree from NPS or Navy sponsored civilian institution* *= 0 otherwise*
PERFORMANCE MODELS	
PROMOTE	*= 1 if promoted to O-4 early or "in zone"* *= 0 otherwise*
LPCTREP	*= percent of all LT FITREPs receiving "recommended for early promotion"*
LASTLTRP	*= 1 if last LT FITREP prior to O-4 selection board received "recommended for early promotion"* *= 0 otherwise*

Figure 4 illustrates the methodology used for the selection model and for the four model specifications for each of the three performance models. Each model and specification will be discussed in the order presented in Figure 4.

1. Selection Model

The Chief of Naval Operations (CNO) states that "selection for Navy funded graduate education will be based on academic capability, outstanding professional performance, promotion potential and a strong educational background." [Ref. 3, p. 2] This reflects the criteria applied by the Navy in selecting candidates for graduate studies. In addition,

SELECTION MODEL [1]

$FFGE = f(Y)$

PERFORMANCE MODELS

1. ***TOTAL EFFECT*** [2]

   $PERF_i = f(FFGE)$

2. ***EFFECT WITH OBSERVED FACTORS*** [3]

   $PERF_i = f(FFGE, X)$

3. ***HECKMAN APPROACH***

   Stage 1: Probit to obtain correction factor, **LAMBDA**.

   Stage 2: $PERF_i = f(FFGE, X, LAMBDA)$

4. ***BARNOW APPROACH*** [4]

   Stage 1: Probit to obtain **PHAT**.

   Stage 2: $PERF_i = f(X, PHAT)$

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[1] *Y represents a vector of explanatory variables.*

[2] *The i performance measures are: **PROMOTE**, **LPCTREP**, and **LASTLTRP**.*

[3] *X represents a vector of explanatory variables.*

[4] ***PHAT** is the probability of FFGE selection for each officer.*

Figure 4. Methodology used in obtaining estimates for the Selection Model and the three Performance Measure Models.

the decision to apply for and undertake graduate studies is a personal decision, which therefore involves a degree of self-selection. The specification of the fully-funded graduate education selection model attempts to capture both sources of selection:

$$FFGE = f(GPA, MATHSKILL, TECHSKILL, EPCTREP, ELIGCURR, EARSWO, EAREOOW, EARTAO)$$

where all variables were defined in Table I.

"Academic capability" and "a strong educational background" were captured by four explanatory variables. The variables, GPA, MATHSKILL, and TECHSKILL are combined to determine one's Academic Profile Code (APC), a three-digit number indicating academic exposure and performance, specifically in math and science. The APC is the sole factor in determining academic qualifications. [Ref. 17] An additional variable, ELIGCURR, delineates the strength of an officer's APC by indicating how many NPS curricula one is eligible for.

Selection for fully-funded graduate education occurs at the O-3 promotion board. Consequently, criteria for "outstanding professional performance" and "promotion potential" are captured by variables indicating early FITREP performance and whether or not an officer achieved early qualifications in SWO, EOOW, or TAO. Inclusion of the early qualification variables also seemed to be plausible proxies (substitutes) for unobserved factors, such as, motivation, desire for achievement, hard working, and confidence, so often associated with those possessing a graduate degree. As discussed earlier, failing to account for these factors could bias the estimated effect of FFGE on performance.

Since FFGE is a binary variable, it is modeled using a nonlinear maximum-likelihood probit procedure, which constrains the predicted values to the measured unit interval of 0 to 1.[13] The FFGE selection probit estimates the impact of each explanatory variable on the likelihood of selection for FFGE and computes predicted probabilities of selection for each officer. The goal would be to have the model correctly predict a high proportion of observations, since this model will play an integral role in determining the presence of selectivity bias.

2. Promotion Model

The first dependent performance measure is a binary variable (PROMOTE=1, else=0), indicating whether an officer promoted to O-4 early or "in zone" (i.e., selected before or during their first year of eligibility). Officers selected late were not considered promotions in this study, since they had failed to promote once already. Each of the four

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13 The probit uses the <u>normal</u> Cumulative Distribution Function (CDF) in estimating the model. Assume we let Y=1 if the officer attained FFGE, and Y=0 if the officer did not. There is an unobservable critical threshold level index, call it I_i^*, such that if I_i exceeds I_i^* the officer will attain FFGE, otherwise he/she will not. Given the assumption of normality, the probability (P_i) that I_i^* is less than or equal to I_i is computed from the standardized normal CDF as:

$$P_i = Pr(Y=1) = Pr(I_i^* \le I_i) = F(I_i) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{I_i} e^{-\frac{t^2}{2}}dt = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\beta_1+\beta_2 X_i} e^{-\frac{t^2}{2}}dt$$

where: t is a standard normal variable and
X represents a vector of explanatory variables.

Here, the probability of attaining FFGE is measured by the area of the standard normal curve from $-\infty$ to I_i. [Ref.20:p. 492] promotion specifications obtain parameter estimates by applying maximum likelihood techniques to a logit model.[14]

a. *Total Effect of FFGE*

This model treats FFGE as if it was the only determinant of promotion to O-4. This is a "naive" model in the sense that it omits all other factors that might affect promotion, and thus illustrates the total impact of FFGE on the likelihood of promotion. However, it is clear that attainment of fully-funded graduate education is not the only contributing factor to promotion. There are other factors that affect promotion and that have an indirect impact on whether or not an officer has FFGE. This model merely establishes that there is a relationship between promotion and FFGE.

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[14] The logit uses the logistic Cumulative Distribution Function to estimate a model. If Y=1 means that an officer was promoted to O-4 and X_i represents a vector of explanatory variables, then the probability that an officer will promote to O-4 (P_i) can be represented by:

$$P_i = E(Y=1|X_i) = \frac{1}{1+e^{-Z_i}}$$

where: $Z_i = \beta_1 + \beta_i X_i$.

This formulation allows Z_i to range from $-\infty$ to $+\infty$, while P_i is restricted between 0 and 1 and is nonlinearly related to Z_i. Although the probit and logit formulations provide quite similar results, the chief difference is that the probit normal curve approaches its limits (0,1) quicker than the logit curve. The choice between the two is one of mathematical convenience and availability of computer programs. In general, the logit model is normally preferred to the probit. [Ref. 20:pp. 481-496] *b. Effect of FFGE With Observed Factors*

The purpose of this model is to illustrate the change in the impact of fully-funded graduate education on promotion when other determinants of promotion are included. The other determinants are described as "observed" because they comprise information readily available to promotion selection boards. The specification of this model is as follows:

PROMOTE = f(FFGE, EPCTREP, LPCTREP, GPA, HISLROTC, HISELOCS, LOSLROTC, LOSELOCS, NESEP, FEMALE, MINORITY, AGENOW, MARONLY, MARCHILD, DIVCHILD, NUC, NOCOMBAT, NODEPHD, EARSWO, EOOWQUAL, TAOQUAL, FYSB85, FYSB86, FYSB87, FYSB88, FYSB89).

Because each of the determinants are correlated, meaning they impact one another indirectly, the estimate of FFGE in this specification represents the direct impact on promotion.

The FITREP performance variables are used to control for an officer's evaluated performance prior to the O-4 promotion board, and as expected, plays a major role in determining the probability of promotion. Other factors included in this specification that may effect the likelihood of promotion are commissioning source by undergraduate college selectivity, various demographic characteristics, the degree of Navy experience, and the fiscal year of one's selection board. When creating dummy variables, it is necessary to omit one of the conditions from the regression so comparisons can be made. Therefore, USNA is the omitted condition within commissioning source, SINGLE is omitted from marital status, and FYSB90 from fiscal year of O-4 promotion board. It is expected that the estimate of FFGE will be considerably less significant than the total effect after accounting for these factors.

Although the results of this model will provide a respectable estimate for FFGE on promotion, the issue of exactly what makes an individual with fully-funded graduate education more promotable/productive is a bit more ambiguous. It may be that the virtual knowledge and responsibility gained through graduate education causes an increase in productivity or, those selected for graduate education may already be more productive due to innate characteristics that make them more motivated and hard working. If the latter is true, the potential for selectivity bias exists and failure to account for these innate characteristics may cause the coefficient for FFGE to be overestimated. There are established procedures designed to introduce these innate characteristics (unobservables) into the regression equation to obtain an unbiased estimate of the treatment (FFGE) effect.

c. Heckman Approach

One way to determine and correct for selectivity bias is based on a two-stage procedure developed by James Heckman, described in Chapter II. The first-stage employs the selection probit model to calculate a correction factor, which incorporates both the unobserved factors (contained in the error structure of the model) and the probabilities of selection for FFGE associated with each officer in a term called LAMBDA. The second-stage calls for running the same model used in specification (b.) with the addition of LAMBDA in the equation. The intent is to purge any correlation between the treatment effect (FFGE) and the error term by introducing part of this error structure into the model. The resulting sign and significance of LAMBDA will determine the extent of selection bias and isolate the true impact of FFGE on promotion.

d. Barnow Approach

A second method to account for selectivity bias is based on another two-stage procedure, developed by Burt Barnow, also described in Chapter II. This procedure is less encompassing than Heckman's and focuses on removing any correlation between the treatment variable (FFGE) and the dependent measure (PROMOTE). This condition of causality is called endogeneity and is a distinct possibility in this study, since 95 percent of those with FFGE were promoted.

The first-stage employs the selection model probit, but in this case, only the probabilities of selection into FFGE associated with each officer are retained in a term called PHAT. The second-stage uses the same model specification in (b.) with the exception of substituting PHAT for FFGE. Restricting the measure of fully-funded graduate education on promotion to the probability of attainment attempts to remove any endogeneity, thus providing a more accurate measure of the impact of FFGE through PHAT.

3. Percent RAP of LT FITREPs Model

A continuous dependent variable, LPCTREP, is used as a second measure of performance. This measure was derived from an identical performance index developed by Idell Neumann at NPRDC. [Ref. 10] As discussed in the previous data section, the dependent measure represents the proportion of all LT FITREPs that received a recommendation for early promotion. The intent of this measure is to capture post-graduate education performance and determine if fully-funded graduate education does in fact enhance the ability to perform at a higher level. Since the dependent variable is linear, ordinary least squares (OLS) is used in obtaining parameter estimates in all specifications.

a. Total Effect of FFGE

This specification, with FFGE as the only explanatory variable, establishes the total impact of fully-funded graduate education on the percentage of LT FITREPs receiving an early recommendation for promotion. A significant positive estimate of FFGE simply means that there is a positive relationship between early promotion recommendations and fully-funded graduate education attainment. However, there are other observed factors that must be considered to further explain early promotion recommendations.

b. Effect of FFGE With Observed Factors

Since LPCTREP is used as one of the factors to explain promotion to O-4 and the same sample population is used in this model, many of the same explanatory variables used in the promotion model are used to explain early promotion recommendations. The specification takes the following form:

LPCTREP = f(FFGE, EPCTREP, GPA, HISLROTC, HISELOCS, LOSLROTC, LOSELOCS, NESEP, FEMALE, MINORITY, AGENOW, MARONLY, MARCHILD, DIVCHILD, NUC, NOCOMBAT, NODEPHD, EARSWO, EOOWQUAL, TAOQUAL).

Since LPCTREP is the dependent measure, it is removed from the right hand side and since the fiscal year of selection board has no effect on FITREP performance, FYSB85-FYSB90 are omitted from this model. As in the promotion model, determinants are correlated to each other, so this specification will reveal the direct impact of FFGE on LPCTREP.

c. Heckman Approach

The same two-stage procedure discussed in the promotion model is used here with the exception of the dependent performance measure (LPCTREP).

d. *Barnow Approach*

This is identical to the two-stage procedure used in the promotion model, except for the dependent performance measure (LPCTREP).

4. Last LT FITREP RAP Model

A binary dependent variable, LASTLTRP, is used as the third and final performance measure. It is based on a FITREP performance index developed by William Bowman of the U.S. Naval Academy. [Ref. 11] The dependent measure indicates whether or not the officer received an early recommendation for promotion on their last LT FITREP prior to the O-4 promotion selection board (LASTLTRP=1, else=0). This last FITREP is considered critical since it completes a trend of either declining or improving performance, unless of course the officer received early recommendations on all FITREPs.

The objective here is similar to the two previous performance measures -- to determine the extent to which fully-funded graduate education explains receiving an early promotion recommendation on the last LT FITREP. Since the dependent measure is binary, nonlinear logit models are used to obtain parameter estimates in all four specifications. Since this measure is also derived from FITREPs, the specification is identical to that used in the LPCTREP model.

a. Total Effect of FFGE

With FFGE as the only explanatory variable, this specification illustrates the total impact of fully-funded graduate educated officers on whether or not the last LT FITREP is recommended for early promotion. This specification establishes the initial relationship between FFGE and LASTLTRP.

b. Effect of FFGE With Observed Factors

Using the same observed factors as the percent RAP of LT FITREPs model, this specification determines the direct impact of FFGE on LASTLTRP when adding other observed factors. Accounting for these other determinants of LASTLTRP and because these other observed factors also have an indirect impact on FFGE, the estimate of FFGE is expected to be considerably less than was found in the total effect specification.

c. Heckman Approach

This is identical to the two-stage Heckman procedure described in the promotion model, with the exception of the dependent performance measure (LASTLTRP).

d. Barnow Approach

This is identical to the two-stage Barnow procedure described in the promotion model, with the exception of the dependent performance measure (LASTLTRP).

By now, it should be obvious that the selection model plays a significant role in determining selection bias. Essentially, the procedures used to account for selectivity bias will only be as effective as the ability to accurately predict fully-funded graduate education selection. However, a potential problem already exists in that, just because one is selected for FFGE does not necessarily mean he or she will choose to pursue it. The data only reflects those selectees who elected to attain fully-funded graduate education; officers meeting the minimum academic and performance criteria electing not to attend FFGE are considered "non-selects."

A final issue deserving of some attention deals with an additional level of selectivity. The Selectivity Bias section in Chapter II addresses a potential limitation of the Heckman procedure if there exists other types of selection, preceding the one in question, that may effect the outcome of the main equation. An officer's decision whether to stay or leave the service at the completion of his/her initial tour of obligation is a selection issue that, in most cases, precedes selection for fully-funded graduate education; the factors explaining this separation behavior may help to explain promotion and performance. Hence, it would seem that a dual selection approach, including both separation and fully-funded graduate education selectivity issues is required. The specification of the separation model focuses on variables that might help to explain an officer's decision to stay or leave early in one's career:

SEP = f(EPCTREP, GPA, HISLROTC, HISELOCS, LOSLROTC,
LOSELOCS, NESEP, FEMALE, MINORITY, AGENOW,
MARONLY, MARCHILD, DIVCHILD, NUC, NOCOMBAT,
EARSWO, EAREOOW, EARTAO).

A nonlinear probit with a binary dependent variable (SEP=1, else=0) was used to obtain an additional correction factor to account for potential selectivity bias associated with separation behavior. A Heckman procedure with correction factors for both separation and FFGE selection (LAMBDA1, LAMBDA2) was run for each performance measure to determine the impact with the additional level of selection. Although this selectivity issue is important, the results are provided in the Appendix since the differences between using this multiple selection approach and the single selection (just FFGE) were minimal.

IV. EMPIRICAL ANALYSIS

A. BIVARIATE ANALYSIS

This section analyzes the sample of 1,477 SWO's extracted from the two original data sources. Since the focus of this study is on officers with fully-funded graduate education, it is useful to examine the means of the three dependent variables (performance measures) and of each explanatory variable for the full sample, and subsamples of those with and without FFGE. Table III displays variable means (and standard deviations) for three groups: (1) those with fully-funded graduate education; (2) those without fully-funded graduate education; and (3) the full sample.

Table III indicates significant differences in the attributes of those with and without FFGE. Analysis of these differences may help identify which variables are likely to have an impact on selection for fully-funded graduate education.

Analysis of the characteristics of the full sample reveals, for example:

- 81.5 percent promoted to O-4
- 71 percent of all LT FITREPs received early promotion recommendations
- 82.9 percent received an early promotion recommendation on the last LT FITREP

- 37 percent of all early (ENS/LTJG) FITREPs were recommended for early promotion
- 30.3 percent were USNA graduates, the most frequent commissioning source
- over 90 percent were male and white
- the average age was 32
- over one-half (52.1 percent) were married with children
- over 90 percent had served on a CRUDES ship
- 74 percent had attended Department Head School
- the majority were not EOOW or TAO qualified, but 57.3 percent had received an early SWO qualification
- the average undergraduate GPA ranged between 2.6 and 3.19
- an officer was eligible for an average of 10 curricula at NPS
- were evenly distributed across fiscal year promotion boards for O-4
- and nearly one-fifth had completed a fully-funded graduate education by the time they were in zone to be considered for O-4.

The mean values of the performance measures by group displayed in Figure 1 of Chapter I indicated sizeable differences in performance in favor of FFGE officers. The performance measure differences suggest that having FFGE has the largest effect on whether or not one gets promoted to O-4, as 95 percent of the officers with FFGE were promoted compared to only 78 percent of the officers without FFGE. The means (in Table III) of the other two FITREP performance measures (LPCTREP and LASTLTRP) also indicates better performance by officers with FFGE; the latter outperformed officers without

FFGE by 10 and 5 percentage points on these two measures, respectively.

TABLE III. MEANS, PROPORTIONS, AND STANDARD DEVIATIONS OF PERFORMANCE MEASURES AND EXPLANATORY VARIABLES FOR THREE SAMPLES.

VARIABLES	MEAN (STANDARD DEVIATION)		
	FFGE SAMPLE (N=282)	NO FFGE SAMPLE (N=1,195)	ALL (N=1,477)
PERFORMANCE MEASURES			
PROMOTE	.950 (.218)	.783 (.412)	.815 (.388)
LPCTREP	.795 (.260)	.696 (.281)	.715 (.279)
LASTLTRP	.865 (.342)	.820 (.384)	.829 (.377)
FITREP PERFORMANCE			
EPCTREP	.509 (.360)	.334 (.369)	.367 (.374)
LPCTREP	.795 (.260)	.696 (.281)	.715 (.297)
COMMISSIONING SOURCE			
HISLROTC	.163 (.370)	.168 (.374)	.167 (.373)
HISELOCS	.128 (.334)	.158 (.365)	.152 (.359)
LOSLROTC	.138 (.346)	.117 (.322)	.121 (.326)
LOSELOCS	.167 (.373)	.274 (.446)	.253 (.435)
USNA	.400 (.491)	.280 (.449)	.303 (.460)
NESEP	.004 (.060)	.003 (.050)	.003 (.052)
PERSONAL DEMOGRAPHICS			
FEMALE	.028 (.166)	.018 (.131)	.020 (.139)
MALE	.972 (.166)	.982 (.131)	.980 (.138)
MINORITY	.064 (.245)	.085 (.278)	.081 (.272)
AGENOW	31.5 (1.92)	32.4 (2.76)	32.2 (2.64)
MARONLY	.270 (.445)	.246 (.431)	.251 (.433)
MARCHILD	.535 (.500)	.518 (.500)	.521 (.500)
DIVCHILD	.012 (.103)	.023 (.151)	.021 (.143)
SINGLE	.184 (.389)	.213 (.410)	.207 (.405)
NAVY EXPERIENCE			
NUC	.100 (.295)	.077 (.267)	.081 (.272)

VARIABLES	MEAN (STANDARD DEVIATION)		
	FFGE SAMPLE (N=282)	NO FFGE SAMPLE (N=1,195)	ALL (N=1,477)
NOCOMBAT	.050 (.216)	.090 (.287)	.083 (.275)
NODEPHD	.160 (.367)	.291 (.456)	.266 (.442)
EOOWQUAL	.535 (.500)	.463 (.499)	.477 (.500)
TAOQUAL	.376 (.485)	.294 (.456)	.309 (.462)
EARSWO	.677 (.468)	.548 (.498)	.573 (.495)
EAREOOW	.174 (.380)	.091 (.288)	.107 (.309)
EARTAO	.035 (.182)	.008 (.086)	.013 (.113)
ACADEMIC PROFILE			
GPA	2.76 (.852)	2.54 (.936)	2.58 (.923)
MATHSKILL	3.57 (1.09)	2.82 (1.55)	2.96 (1.50)
TECHSKILL	1.68 (1.37)	1.10 (1.33)	1.21 (1.36)
ELIGCURR	11.9 (9.29)	9.97 (8.39)	10.3 (8.60)
FY OF O-4 SELECTION BOARD			
FYSB85	.043 (.202)	.056 (.230)	.053 (.225)
FYSB86	.181 (.386)	.198 (.399)	.195 (.396)
FYSB87	.234 (.426)	.182 (.386)	.192 (.394)
FYSB88	.153 (.360)	.136 (.343)	.139 (.347)
FYSB89	.188 (.391)	.236 (.425)	.227 (.419)
FYSB90	.199 (.400)	.192 (.394)	.193 (.395)
TREATMENT VARIABLE			
FFGE	------	------	.191 (.393)

Table III further reveals that performance on ENS/LTJG FITREPs (EPCTREP) may be an important factor in FFGE selection, since those who ultimately were selected for graduate education were more likely to have been recommended for accelerated promotion on their early FITREPs. Mean values of commissioning source and college quality reveal that Naval

Academy graduates are the most likely to be selected for FFGE, comprising 40 percent of the subsample of officers with FFGE and only 28 percent of those without. OCS commissioned officers from lower quality colleges (LOSELOCS) are least likely to be selected, comprising only 16.7 percent of those with FFGE and 27 percent of those without. Although females comprise only 2 percent of the whole sample, they represent 2.8 percent of all those selected for FFGE, suggesting that a greater proportion of females are selected for fully-funded graduate education. A lower percentage of minorities, 2 percentage points less, are selected for FFGE compared to those without; and selection for FFGE seems to favor officers who are married (with or without children) compared to those who are divorced or single.

As mentioned in Chapter III, academic experience and professional performance are important criteria for selection into the Navy's FFGE program. Table III seems to support this criteria in that, among FFGE officers, those with an early SWO qualification, an early EOOW qualification, and an early TAO qualification are more heavily represented. Furthermore, those selected for FFGE have higher averages in all three Academic Profile Code areas, with the largest difference in math skills, and are eligible for an average of two more NPS curricula than those without FFGE.

The increase in the percentage of officers selected for FFGE during fiscal year promotion board 1987 and 1988 most likely can be attributed to the increased emphasis in graduate education just after fiscal year 1985, when the Navy experienced difficulty meeting graduate education quotas.[15]

Cross-tabulations of explanatory variable categories by each of the three performance measures further substantiates the consistent superior performance (in promotion and percentage of LT FITREPs recommended for early promotion) for officers with fully-funded graduate education. However, the third performance measure, indicating whether or not the last LT FITREP received an early recommendation for promotion, seems to be somewhat inconsistent compared to the other two. Table IV illustrates performance differences between those with FFGE and those without for each performance measure by commissioning source, personal demographics, and Navy experience.

As can be seen in Table IV, officers with FFGE generally tend to perform better in promotion and LPCTREP regardless of the commissioning source, personal demographics, and extent of Navy experience. Contrary to the first two performance measures, performance on the LASTLTRP seems to be somewhat unpredictable, where a higher percentage of officers without FFGE received early promotion recommendations on their last LT FITREP in all three of the explanatory variable categories.

[15] In the Navy Graduate Education Program Status Report for FY 1984, prepared by the Naval Postgraduate School, references are made to the chronic difficulties the Navy experienced with meeting graduate education quotas between years 1979 and 1983. [Ref. 18]

This could imply that using a single FITREP, regardless of how important it is, may not be as reliable or encompassing in evaluating an officer's overall performance.

TABLE IV. PERFORMANCE DIFFERENCES BY GRADUATE EDUCATION ACROSS COMMISSIONING SOURCE, PERSONAL DEMOGRAPHICS, AND NAVY EXPERIENCE. *

VARIABLE	PROMOTE		LPCTREP		LASTLTRP	
	FFGE	NO FFGE	FFGE	NO FFGE	FFGE	NO FFGE
HISLROTC	93.5	77.1	77.7	67.5	87.0	80.1
HISELOCS	94.4	80.42	81.2	70.5	80.6	81.5
LOSLROTC	92.3	77.1	75.8	66.0	84.6	82.1
LOSELOCS	91.5	75.8	72.2	68.9	76.6	81.7
NESEP -	100.0	66.7	100.0	58.2	100.0	100.0
USNA	98.2	80.9	83.9	72.8	92.9	83.6
FEMALE -	100.0	90.5	83.5	63.2	75.0	81.0
MALE	94.9	78.1	79.8	69.7	86.9	82.0
MINORITY	88.9	73.3	83.3	59.4	94.4	72.3
WHITE	95.5	78.8	79.2	70.6	86.0	82.9
MARONLY	94.7	77.2	76.5	71.1	84.2	87.1
MARCHILD	95.4	80.8	82.5	70.6	91.4	82.6
DIVCHILD -	100.0	75.0	86.7	57.2	100.0	71.4
SINGLE	94.2	74.0	74.8	66.9	75.0	76.0
NUC	100.0	95.7	78.9	71.2	85.2	88.0
NON-NUC	94.5	76.9	79.6	69.5	86.7	81.5
NOCOMBAT	100.0	51.9	82.9	53.7	85.7	70.4
COMBAT	94.8	81.0	79.3	71.2	86.6	83.2
NODEPHD	93.3	52.6	77.3	57.7	80.0	70.1
DEPHD	95.4	88.9	79.9	74.5	87.8	86.9
EOOWQUAL	96.7	89.0	85.0	76.0	91.4	89.0
NOEOOWQUAL	93.1	69.2	73.2	64.2	80.9	76.0

VARIABLE	PROMOTE FFGE	PROMOTE NO FFGE	LPCTREP FFGE	LPCTREP NO FFGE	LASTLTREP FFGE	LASTLTREP NO FFGE
TAOQUAL	100.0	90.9	87.3	79.7	93.4	92.3
NOTAOQUAL	92.1	73.1	74.8	65.4	82.4	77.3
EARSWO	95.8	83.4	82.1	76.2	86.4	84.4
NOEARSWO	93.4	72.2	74.1	61.7	86.8	79.1
EAREOOW	91.8	89.9	81.9	77.6	85.7	90.8
NOEAREOOW	95.7	77.2	79.0	68.8	86.7	81.1
EARTAO -	100.0	77.8	100.0	90.4	100.0	100.0
NOEARTAO	94.9	78.3	78.8	69.5	86.0	81.9

* All figures are in percentages.
\- Observations represent less than 3 percent of the sample.

More specifically, Table IV illustrates that USNA graduates, with or without FFGE, tend to perform better than ROTC and OCS commissioned officers, regardless of undergraduate college quality. This holds true for all three performance measures. Additionally, OCS officers, with or without FFGE who attended a highly competitive undergraduate college seem to outperform ROTC officers in promotion and LPCTREP; however, OCS officers who attended a less competitive college tend to perform the worst in all three performance measures.

Personal demographic characteristics cross-tabulated with performance measures reveal that females with or without FFGE, although representing only 2 percent of the sample, tend to outperform males with and without FFGE in promotion by 5 and 12 percentage points, respectively. In the LPCTREP measure, females with FFGE outperform males with FFGE by 4 percentage points. However, males with or without FFGE seem to fare better in the LASTLTRP performance measure. The cross-tabulation further reveals that minority Surface Warfare officers generally perform more poorly on all three performance measures, unless he/she has FFGE; minorities with FFGE outperformed whites with FFGE in the LPCTREP and LASTLTRP performance measures. Although outside the scope of this thesis, an interesting question is why minorities with FFGE fail to promote as favorably as whites with FFGE, even though they maintain higher fitness report scores. This is a topic for further research. Finally, officers married with children generally perform better than officers married with no children, divorced, or single.

With the exception of fitness report performance, the extent of one's Navy experience is probably the most revealing factor in each performance measure. Table IV reveals an interesting trend within Navy experience, indicating that certain attributes considered as career-enhancing have a stronger effect on performance measures for non-FFGE officers than for FFGE officers. Non-FFGE officers having one or more of the following attributes -- nuclear power trained, served on a CRUDES ship, attended Department Head school, EOOW qualified, TAO qualified, and received an early SWO, EOOW, or TAO qualification -- averaged at least 10 percentage points better on all three performance measures than non-FFGE officers without the preceding attributes. On the other hand, performance measure differences for officers with FFGE possessing career enhancing attributes compared to those without the attributes were much smaller in magnitude, suggesting that attainment of a fully-funded graduate education may compensate for failure to achieve certain qualifications and experience vital in a Surface Warfare officer's career. For example, non-FFGE officers who attended Department Head school promoted 34 percentage points higher than non-FFGE officers who did not attend Department Head school, while FFGE officers with Department Head school promoted only 2 percentage points higher than FFGE officers without Department Head school. Similar differences are evident within each of the other two performance measures and throughout all the Navy experience variables.

In concluding the bivariate analysis, Tables III and IV clearly suggest that attainment of a fully-funded graduate education is advantageous in promotion to O-4 and contributes to receiving early promotion recommendations on LT FITREPs. However, the impact of FFGE on receiving an early promotion recommendation on the last LT FITREP is questionable. Although this form of analysis is suggestive, in order to obtain a more reliable estimate of the impact of fully-funded graduate education on the performance measures, one must simultaneously incorporate the effects of all the explanatory variables by holding each constant. A more advanced statistical technique, multivariate regression analysis, enables one to do this and is the subject of the next section.

B. MULTIVARIATE ANALYSIS

Four main models, discussed in the methodology section of Chapter III, are used to evaluate the impact of fully-funded graduate education on Surface Warfare officer performance. The dependent variable, FFGE, for the selection model is coded =1 for those with fully-funded graduate education and =0 otherwise. Since the dependent variable is binary, a maximum likelihood technique is used to estimate a probit model of selection for fully-funded graduate education. The first performance model uses the "in-zone" or "below-zone" promotion outcome to O-4 as the dependent variable and is estimated using a logit model, where PROMOTE=1 for those who are promoted and =0 otherwise. The second performance measure uses the percent of LT FITREPs receiving an early promotion recommendation (LPCTREP) as the dependent variable. Since the dependent variable is continuous, the model is estimated using linear ordinary least squares (OLS) regression techniques. The third performance measure uses the recommendation for early promotion on the last LT FITREP as the dependent variable. This dependent variable, LASTLTRP, is coded =1 if the officer's last LT FITREP received a RAP and =0 otherwise. Since the dependent variable is binary, the logit technique is used to estimate the model.[16] This section presents the multivariate results of the selection model and the three performance models, where the specifications were defined in Chapter III.[17]

A separate table is presented for each estimated model and displays the signs and magnitudes of the estimated coefficients, the t-statistics, and, for the nonlinear models, the change in probabilities associated with a one unit change in each explanatory variable; holding other variables constant.

1. Estimates of the Selection Model

As was discussed in Chapters II and III, the selection probit is vital in determining the presence of selectivity bias associated with selection into the Navy's fully-funded graduate education program. The probit incorporates the unobserved factors gathered from the error structure, which is

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[16] Nonlinear probit or logit functional forms are superior to linear OLS functions when the dependent variable is binary because they constrain the predicted values to the unit interval (0,1) so that the expected value can be interpreted as the probability of the event occurring. Although both nonlinear functions produce similar results, the logit is preferred since it is easier to interpret and convert to changes in probabilities. [Ref. 19] The probit is used for the FFGE selection model because of its ability to incorporate unobserved characteristics -- hence the model of choice in the first stage of the two-stage procedures to deal with selectivity bias.

[17] William H. Greene's Econometric Software package, LIMDEP, was used to obtain estimates for all models in this thesis. [Ref. 15] Greene is considered one of the best known sources for econometric techniques currently "in vogue."

based on the calculated probability of selection into FFGE associated with each observation, into an additional term called LAMBDA.[18] This term is then used in the performance models to adjust for potential selectivity bias in the estimated effect of graduate education on performance.

Table V displays the results of the probit selection model, the specification of which was expressed mathematically in Chapter II. The specification of the model was discussed further in Chapter III. In Table V, seven of the eight variables used to explain FFGE selection were statistically significant. The positive signs of the significant variables indicated significant positive impacts on the likelihood of selection for fully-funded graduate education. Out of the three variables comprising the Academic Profile Code, performance in math (MATHSKIL) seemed to be the most important, with a one percent increase in math index score increasing the probability of FFGE attainment by 4.4 percent. Performance on early (ENS/LTJG) FITREPs and attaining an early TAO qualification had the largest impact on selection for FFGE, with a one percent increase in the percent of early FITREPs recommended for early promotion increasing the probability of selection by 10.8 percent; an officer with an early TAO qualification was 16.8 percent more likely to be selected.

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[18] See Section D of Chapter II for mathematical interpretation of obtaining LAMBDA.

TABLE V. PROBIT ESTIMATES OF THE SELECTION MODEL. [1]

VARIABLE	ESTIMATED COEFFICIENT	CHANGE IN PROBABILITY [2]
GPA	.110 (2.19) *	.027
MATHSKIL	.176 (4.79) **	.044
TECHSKIL	.054 (1.51)	.013
EPCTREP	.439 (5.37) **	.108
ELIGCURR	.013 (2.65) **	.003
EARSWO	.264 (3.12) **	.065
EAREOOW	.307 (2.58) **	.076
EARTAO	.680 (2.19) *	.168
INTERCEPT	-2.36 (-12.43)	----
CHI-SQUARE LOG LIKELIHOOD	149.88**	
PREDICTION RATIO [3]	81.0%	

[1] t-statistic in parentheses measures significance of coefficient.
[2] Calculated by multiplying the estimated coefficient by the density of the standard normal distribution function corresponding to the particular probability level, as given by the cumulative normal distribution function for which the change is being evaluated. [Ref. 19]
[3] Ratio of correct predictions over total number of observations.
Note: 98.6% of those without FFGE were correctly predicted, but only 6.7% of those with FFGE were predicted correctly. Additionally, out of the actual 19% that had FFGE, the model only predicted a mere 2.4% to have FFGE.
* Significant at the .05 level.
** Significant at the .01 level.

In evaluating the goodness-of-fit of the model, the chi-square log-likelihood statistic is used to test a null hypothesis that all variables are simultaneously equal to zero. Although this test is considered weak because a model rarely, if ever, fails to meet the criteria, the Log-Likelihood value of 149.88 was highly significant (at the .01 level), which rejects the null statistically and indicates that the included variables are related as a whole to FFGE selection.

The predictive ability of the model, indicated by the prediction ratio, is another way to evaluate model fit. Since the selection model correctly predicted 81 percent of those with and without FFGE, the model appears to be reasonably accurate. However, further analysis of correct prediction percentages revealed that 98.6 percent of those without FFGE were predicted correctly, but the model was only able to correctly predict 6.7 percent of those with FFGE. Although 19 percent of the sample actually had FFGE, the model predicted a dismal 2.4 percent to have FFGE. These poor prediction percentages may reduce the effectiveness of the procedures used to correct for potential bias associated with FFGE selection.

While the variables included in this model appear to be important, we still do not know how accurate this selection model is as a representation of the true selection process via which individuals choose, and the Navy decides to assign individuals to graduate education programs. In particular, other important variables relevant to the selection process are likely omitted, which could bias the effect of the included variables. [Ref. 16] The key issue is whether the true selection process has been captured by this model. Unfortunately, the "true" selection model is unknown. For the purposes of testing for selectivity bias, we will assume this model accurately captures this process.

2. Estimates of the Promotion Model

Table VI displays the estimated logit coefficients from the four alternative specifications of the O-4 promotion model. The specifications are designed to illustrate the marginal effect of the impact of FFGE on promotion as observed and unobserved factors are introduced into the equation. The first model specification measures the total effect of FFGE on promotion by using FFGE as the only explanatory variable, and the second measures the direct effect by including additional observed factors that may impact promotion. The last two model specifications are developed from two techniques used to determine and correct for the presence of the potential bias associated with fully-funded graduate education selection by incorporating into the model unobserved factors and probabilities for FFGE selection for each observation (the selection approaches are discussed fully in Chapter II).

TABLE VI. LOGIT ESTIMATES OF THE PROMOTION MODEL.

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
INTERCEPT	1.29 (18.30) ---	1.49 (1.01) ---	1.45 (.969) ---	1.75 (1.17) ---
EPCTREP	--- --- ---	1.02 (4.43)** [.154]	.991 (3.72)** [.149]	1.07 (3.97)** [.161]
LPCTREP	--- --- ---	2.14 (10.36)** [.323]	2.14 (10.37)** [.323]	2.13 (10.39)** [.321]
GPA	--- --- ---	.095 (.934) [.014]	.088 (.814) [.013]	.105 (.963) [.016]
HISLROTC	--- --- ---	.018 (.062) [.003]	.024 (.082) [.004]	.001 (.002) [.000]
HISELOCS	--- --- ---	.300 (.914) [.045]	.320 (.926) [.048]	.301 (.877) [.045]
LOSLROTC	--- --- ---	-.364 (-1.18) [-.055]	-.356 (-1.14) [-.054]	-.349 (-1.12) [-.053]
LOSELOCS	--- --- ---	.242 (.764) [.037]	.263 (.781) [.040]	.241 (.722) [.036]
NESEP	--- --- ---	-.350 (-.258) [-.053]	-.331 (-.244) [-.050]	-.415 (-.306) [-.063]
FEMALE	--- --- ---	3.01 (3.17)** [.454]	3.01 (3.18)** [.454]	3.04 (3.25)** [.458]
MINORITY	--- --- ---	.182 (.590) [.027]	.181 (.586) [.027]	.130 (.424) [.020]
AGENOW	--- --- ---	-.092 (-2.04)* [-.014]	-.091 (-2.02)* [-.014]	-.099 (-2.19)* [-.015]
MARONLY	--- --- ---	.365 (1.41) [.055]	.365 (1.41) [.055]	.395 (1.53) [.060]
MARCHILD	--- --- ---	.607 (2.58)** [.092]	.606 (2.58)** [.091]	.622 (2.66)** [.094]

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
DIVCHILD	--- --- ---	.439 (.654) [.066]	.428 (.635) [.065]	.390 (.583) [.059]
NUC	--- --- ---	2.40 (4.08)** [.362]	2.39 (4.07)** [.360]	2.42 (4.10)** [.365]
NOCOMBAT	--- --- ---	-1.22 (-3.93)** [-.184]	-1.22 (-3.93)** [-.184]	-1.26 (-4.08)** [-.190]
NODEPHD	--- --- ---	-1.80 (-9.35)** [-.271]	-1.80 (-9.34)** [-.271]	-1.84 (-9.61)** [-.277]
EARSWO	--- --- ---	-.143 (-.737) [-.022]	-.156 (-.754) [-.024]	-.125 (-.600) [-.019]
EOOWQUAL	--- --- ---	.658 (3.32)** [.100]	.654 (3.28)** [.099]	.665 (3.35)** [.100]
TAOQUAL	--- --- ---	.731 (3.05)** [.110]	.732 (3.06)** [.110]	.730 (3.07)** [.110]
FYSB85	--- --- ---	2.20 (4.24)** [.332]	2.20 (4.24)** [.332]	2.22 (4.30)** [.335]
FYSB86	--- --- ---	1.17 (3.69)** [.176]	1.17 (3.70)** [.176]	1.19 (3.77)** [.179]
FYSB87	--- --- ---	1.22 (3.99)** [.184]	1.23 (4.00)** [.185]	1.23 (4.05)** [.185]
FYSB88	--- --- ---	.198 (.627) [.030]	.200 (.635) [.030]	.189 (.602) [.028]
FYSB89	--- --- ---	.384 (1.41) [.058]	.385 (1.41) [.058]	.381 (1.40) [.057]
FFGE	1.67 (5.89)** [.252]	.902 (2.73)** [.136]	1.15 (.837) [.173]	--- --- ---
LAMBDA	--- --- ---	--- --- ---	-.141 (-.184) [-.021]	--- --- ---

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
PHAT	--- --- ---	--- --- ---	--- --- ---	.221 (.169) [.033]
CHI-SQUARED LL	53.18**	577.79**	577.83**	569.28**
PREDICTION RATIO	81.5 %	89.2 %	89.1 %	88.6 %

[1] First figure is logit coefficient estimate, the t-statistic is in parentheses, and the change in probability obtained by multiplying the coefficient by Px(1-P) is in brackets, where P is percent of sample promoted (.815). [Ref. 19]
* Significant at the .05 level.
** Significant at the .01 level.

a. Total Effect of FFGE

The first column in Table VI displays the results of the total effect of FFGE on promotion. As can be seen, having fully-funded graduate education was highly significant in this model specification. If one were to consider FFGE as the only factor explaining promotion to O-4, then an officer with FFGE would be 25.2 percent more likely to promote, compared to an officer without FFGE. However, as discussed in Chapter III, there are other observed or measurable factors that contribute to promotion.

b. Effect of FFGE with Observed Factors

The second column of Table VI displays the results of the direct effect of FFGE on promotion to O-4 after including numerous other explanatory variables that have both a direct impact on promotion and an indirect impact on selection for FFGE. As can be seen, although still highly significant, the magnitude of the impact of FFGE on promotion has decreased dramatically compared to the impact in the total effect specification. Inclusion of the observed factors in the model approximately halved the probability of promotion for FFGE officers, or by 11.6 percentage points, from 25.2 percent in the total effect specification to only 13.6 percent in the specification with observed factors. Cymrot's study on the effects of graduate education on promotion, presented in Chapter II [Ref. 2], revealed a 26 percent increase in the probability of promotion to O-4. However, his model suffered from misspecification due to the mixing of officers from all communities, which can mask important community-specific factors, and not accounting for other observed factors significant in explaining promotion, such as fitness reports and Navy experience. He included only personal demographics, time in rank, service continuity, and officer community designator.

Of the other observed factors included in the specification in column 2 of Table VI, 13 had statistically significant impacts on promotion. The percent of LT FITREPs recommended for early promotion (LPCTREP) had the largest effect, with a one percent increase in this percentage increasing the probability of promotion to O-4 by 32.3 percent, while a one percent increase in the percent of "early" FITREPs RAP'd was associated with only a 15.4 percent increase in promotion probability. Personal demographic variables revealed significant effects on promotion for females, who were 45.4 percent more likely to promote than males, and those married with children, who were 9.2 percent more likely to promote than single officers. All but one of the Navy experience variables (EARSWO) had significant effects on promotion. Nuclear officers were 36.2 percent more likely to promote than conventional officers; officers not serving on a CRUDES ship were 18.4 percent less likely to promote; not attending Department Head school before the O-4 promotion board decreased the probability of promotion by 27.1 percent; and achieving an EOOW or TAO qualification increased one's promotion probability by 10 percent. Finally, there were significant positive fiscal year effects for 1985, 1986, and 1987 (compared to 1990). Given these significant variables, the multivariate results seem to be consistent with the bivariate indications.

c. *Heckman Approach*

The third column of Table VI displays the results of the Heckman approach, the first of two techniques used to correct for potential selection bias. Coefficient estimates for all the observed factors, including signs and measure of significance are nearly identical to those in the model specification in column 2 with one notable exception, the estimated effect of FFGE. The introduction of unobserved factors (contained in LAMBDA) based on the probability of FFGE selection for each officer, obtained from the probit selection model, resulted in FFGE having an insignificant impact on promotion. A change in the significance of the treatment variable (FFGE) is generally an indication that selection bias was present in the model and a statistically significant estimate of the correction factor (LAMBDA) would provide confirmation. However, the estimate for LAMBDA was insignificant -- that is, no selection bias was detected.

Due to the insignificance of LAMBDA, very little can be said concerning the implications of the change in the FFGE estimate. Although the results of the Heckman procedure implies that FFGE adds no value to promotion, the inability to identify (predict) those officers with FFGE in the selection model reduces the level of confidence placed on the results of the Heckman procedure. Since detection of selection bias is highly dependent on an accurate specification of the selection probit, one can only speculate that there are unidentified variables omitted from the probit selection model that would help to explain FFGE selection more accurately.

d. Barnow Approach

The fourth column of Table VI displays the results of an alternative technique to correct for the presence of potential selection bias. As discussed in Chapter III, instead of using FFGE, this model specification utilizes the calculated probabilities of FFGE selection for each officer, obtained from the selection probit, in a new explanatory term called PHAT. This purges the equation of any endogeneity between promotion and FFGE; which could potentially bias the estimate of FFGE on promotion.

As was the case in the Heckman approach, the coefficient estimates, signs, and measure of significance for all the observed factors are nearly identical to those obtained in column 2. The coefficient of PHAT was similar to that of FFGE in the Heckman model, positive but statistically insignificant. Again, given the poor predictive ability of the selection probit, the reliability of this model is somewhat questioned.

3. Estimates of the Percent RAP of LT FITREPs Model

Table VII displays the ordinary least squares (OLS) model results for each of the four specifications of the impact of FFGE on the percent of LT FITREPs receiving an early promotion recommendation. Since most officers attain FFGE at the five or six-year point, this measure intends to evaluate post-FFGE performance. As in the promotion model, the four model specifications are designed to illustrate the marginal effect of FFGE on LT FITREP performance as observed, and then unobserved, factors are introduced into the model.

TABLE VII. OLS ESTIMATES OF THE PERCENT OF LT FITREPS RAP MODEL

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS [1]	HECKMAN APPROACH	BARNOW APPROACH
INTERCEPT	.787 (69.66)	.828 (5.43)	.848 (5.56)	.859 (5.58)
EPCTREP	--- ---	.126 (6.19)**	.143 (5.84)**	.141 (5.67)**
GPA	--- ---	.008 (.720)	.012 (1.06)	.012 (1.03)
HISLROTC	--- ---	-.007 (-.240)	-.011 (-.360)	-.011 (-.358)
HISELOCS	--- ---	-.008 (-.231)	-.020 (-.575)	-.018 (-.521)
LOSLROTC	--- ---	-.058 (-1.79)	-.062 (-1.92)	-.062 (-1.90)
LOSELOCS	--- ---	-.015 (-.468)	-.028 (-.840)	-.026 (-.772)
NESEP	--- ---	.004 (.023)	-.002 (-.013)	-.003 (-.015)
FEMALE	--- ---	.133 (1.66)	.130 (1.63)	.135 (1.69)
MINORITY	--- ---	-.050 (-1.41)	-.049 (-1.40)	-.051 (-1.42)
AGENOW	--- ---	-.006 (-1.21)	-.006 (-1.30)	-.007 (-1.37)
MARONLY	--- ---	.026 (.911)	.026 (.921)	.027 (.940)
MARCHILD	--- ---	.030 (1.17)	.030 (1.18)	.031 (1.20)
DIVCHILD	--- ---	-.133 (-1.93)	-.129 (-1.89)	-.130 (-1.89)
NUC	--- ---	.078 (1.92)	.081 (1.99)	.081 (1.97)
NOCOMBAT	--- ---	-.097 (-2.43)*	-.097 (-2.44)*	-.099 (-2.47)*
NODEPHD	--- ---	-.139 (-5.89)**	-.137 (-5.81)**	-.139 (-5.89)**
EARSWO	--- ---	.113 (5.52)**	.121 (5.62)**	.120 (5.53)**

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
EOOWQUAL	--- ---	.089 (4.45)**	.092 (4.60)**	.091 (4.52)**
TAOQUAL	--- ---	.061 (2.80)**	.061 (2.82)**	.061 (2.82)**
FFGE	.113 (4.38)**	.022 (.869)	-.113 (-1.03)	--- ---
LAMBDA	--- ---	--- ---	.081 (1.26)	--- ---
PHAT	--- ---	--- ---	--- ---	-.102 (-.875)
ADJUSTED R-SQUARED [2]	.012	.156	.157	.156
F-STATISTIC [2]	19.17**	14.66**	14.04**	14.66**

[1] First figure is OLS coefficient estimate and represents the percent change of LT FITREPs rapped associated with a one unit increase in the variable, the t-statistic is in parentheses.
[2] Adjusted R-Squared and F-Statistic indicate goodness-of-fit for a linear model estimated by OLS.
* Significant at the .05 level.
** Significant at the .01 level.

a. Total Effect of FFGE

Column 1 of Table VII displays the results of the total effect of FFGE on the percent of LT FITREPs receiving a RAP (LPCTREP). As Table VII shows, FFGE had a significant positive impact on LPCTREP, when used as the only explanatory variable. Officers with FFGE received 11.3 percent more LT FITREPs with a recommendation for early promotion. In order to obtain a more accurate estimate of the effect of FFGE on LPCTREP, other observed factors that also effect LPCTREP must be incorporated into the model.

b. Effect of FFGE with Observed Factors

Column 2 of Table VII displays the results of the direct effect of FFGE on the percent of LT FITREPs receiving early promotion recommendations after including numerous other explanatory variables that have both a direct impact on LPCTREP and an indirect impact on selection for FFGE. The statistical insignificance of FFGE in column 2 implies that FFGE plays a negligible role in determining LT FITREP performance when other observed explanatory factors are included in the model. This result seems to conflict with what was implied in the bivariate analysis, where officers with FFGE appeared to perform significantly better on LT FITREPs in all the variables. It should be noted, however, the value that FFGE adds to the propensity of attaining early promotion recommendations on LT FITREPs cannot be discounted, due to the fact that FFGE became insignificant only after accounting for Navy experience in the model.

Of the other observed factors, only early FITREP performance and Navy experience variables had statistically significant impacts on LPCTREP. A one percent increase in the percent of early (ENS/LTJG) FITREPs recommended for early promotion (EPCTREP) was associated with a 12.6 percent increase in LPCTREP. The significant Navy experience variables revealed that not serving on a CRUDES ship and not attending Department Head school decreased LPCTREP by 9.7 and 13.9 percentage points, respectively; achieving an early SWO qualification, an EOOW qualification, and a TAO qualification increased LPCTREP by 11.3, 8.9, and 6.1 percentage points, respectively. Although the adjusted R-squared was fairly low, the F-statistic was highly significant at the .01 level, indicating a good fit.

c. Heckman Approach

Column 3 of Table VII displays the results obtained when incorporating unobserved factors based on the probabilities of FFGE selection for each officer into the model to correct for potential selection bias. The parameter estimates and statistical significance of all the observed factors, except for FFGE, were nearly identical to those obtained in column 2. As was the case in the promotion model, the correction factor (LAMBDA) and FFGE were statistically insignificant to the .05 level; however, the change in sign (to negative) of the FFGE variable and the somewhat high t-scores for both FFGE and LAMBDA (>1.0), suggests that attainment of a FFGE degree could possibly hurt post-FFGE FITREP performance when accounting for unobserved factors in the model.

d. Barnow Approach

Column 4 in Table VII displays the results of the second technique used to correct for potential selection bias in the LPCTREP model. As in the Heckman estimates in column 3, the parameter estimates and statistical significance for all the observed factors, except FFGE, were virtually identical to those obtained in column 2. As was the case in the promotion model, the impact of FFGE, represented by the probability of attaining FFGE (PHAT), was statistically insignificant after correcting for the endogeneity of selection for FFGE. Consistent with the Heckman approach, the impact of FFGE became negative, although statistically insignificant, suggesting that FFGE could be detrimental to post-FFGE FITREP performance.

4. Estimates of the Last LT FITREP RAP Model

Table VIII displays the logit model results for each of the four model specifications used to measure the marginal effect of FFGE on the probability of receiving an early promotion recommendation on the last LT FITREP. As discussed in Chapter III, this single FITREP is used as a performance measure because it evaluates post-FFGE performance and completes a trend of either declining, improving, or sustained LT FITREP performance crucial in determining promotion to O-4.

TABLE VIII. LOGIT ESTIMATES OF THE LAST LT FITREP RAP MODEL.

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
INTERCEPT	1.52 (20.14) ---	1.50 (1.31) ---	1.49 (1.29) ---	1.42 (1.23) ---
EPCTREP	--- --- ---	.723 (4.17)** [.103]	.717 (3.49)** [.102]	.697 (3.33)** [.100]
GPA	--- --- ---	-.003 (-.039) [-.000]	-.005 (-.053) [-.001]	-.008 (-.090) [-.001]
HISLROTC	--- --- ---	-.089 (-.388) [-.013]	-.088 (-.381) [-.012]	-.081 (-.353) [-.011]
HISELOCS	--- --- ---	-.344 (-1.32) [-.049]	-.340 (-1.26) [-.048]	-.334 (-1.23) [-.047]
LOSLROTC	--- --- ---	-.253 (-.992) [-.036]	-.252 (-.984) [-.036]	-.251 (-.975) [-.036]
LOSELOCS	--- --- ---	-.276 (-1.09) [-.039]	-.271 (-1.02) [-.038]	-.261 (-.981) [-.037]
NESEP	--- --- ---	9.95 (.063) [1.00]	9.96 (.063) [1.00]	9.95 (.063) [1.00]
FEMALE	--- --- ---	.220 (.390) [.031]	.221 (.392) [.031]	.190 (.338) [.027]
MINORITY	--- --- ---	-.497 (-2.01)* [-.070]	-.497 (-2.01)* [-.070]	-.490 (-1.98)* [-.069]
AGENOW	--- --- ---	-.019 (-.514) [-.003]	-.019 (-.510) [-.003]	-.017 (-.461) [-.002]
MARONLY	--- --- ---	.748 (3.46)** [.106]	.748 (3.46)** [.106]	.743 (3.44)** [.105]
MARCHILD	--- --- ---	.581 (3.14)** [.082]	.581 (3.14)** [.082]	.576 (3.12)** [.082]
DIVCHILD	--- --- ---	-.220 (-.444) [-.031]	-.211 (-.446) [-.030]	-.207 (-.438) [-.029]

VARIABLE	TOTAL EFFECT [1]	DIRECT EFFECT [1]		
		OBSERVED FACTORS	HECKMAN APPROACH	BARNOW APPROACH
NUC	--- --- ---	.171 (.504) [.024]	.170 (.499) [.024]	.162 (.476) [.023]
NOCOMBAT	--- --- ---	-.160 (-.615) [-.023]	-.160 (-.615) [-.023]	-.150 (-.575) [-.021]
NODEPHD	--- --- ---	-.702 (-4.28)** [-.100]	-.703 (-4.27)** [-.100]	-.690 (-4.22)** [-.098]
EARSWO	--- --- ---	-.056 (-.363) [-.008]	-.059 (-.359) [-.008]	-.067 (-.399) [-.010]
EOOWQUAL	--- --- ---	.707 (4.26)** [.100]	.706 (4.22)** [.100]	.704 (4.20)** [.100]
TAOQUAL	--- --- ---	.926 (4.49) [.131]	.926 (4.49)** [.131]	.922 (4.46)** [.131]
FFGE	.343 (1.80) [.049]	-.163 (-.786) [-.023]	-.114 (-.120) [-.016]	--- --- ---
LAMBDA	--- --- ---	--- --- ---	-.029 (-.053) [-.004]	--- --- ---
PHAT	--- --- ---	--- --- ---	--- --- ---	.064 (.064) [-.009]
CHI-SQUARED LL	3.44	156.56**	156.56**	155.96**
PREDICTION RATIO	82.9 %	83.5 %	83.5 %	83.5 %

[1] First figure is logit coefficient estimate, the t-statistic is in parentheses, and the change in probability obtained by multiplying the coefficient by Px(1-P) is in brackets, where P is the percent of the sample receiving a RAP (.829).
* Significant at the .05 level.
** Significant at the .01 level.

a. *Total Effect of FFGE*

Column 1 of Table VIII displays the logit results when FFGE is used as the only explanatory variable for the probability of receiving an early promotion recommendation on the last LT FITREP (LASTLTRP). As discussed in Chapter III, the significance of FFGE in this total effect specification merely establishes a relationship between the performance measure and FFGE. Although FFGE had a rather high t-score, it was statistically insignificant to the .05 level. It is likely that FFGE will have no effect on LASTLTRP within the three remaining model specifications, due tc s poor representation in the total effect specification. Although the predictive ability of the specification was good, with a correct prediction ratio of 82.9 percent, the low Chi-Square statistic of only 3.44 was insignificant, indicating a poor fit.

b. Effect of FFGE with Observed Factors

Column 2 of Table VIII displays the LASTLTRP logit results after including other observed factors that help to explain whether or not a SWO receives an early promotion recommendation on the last LT FITREP. As expected, FFGE had a statistically insignificant impact, which seems to be consistent with the bivariate analysis, where the mean LASTLTRP performance differences between those with and without FFGE were not that great. Of the statistically significant variables, achieving a TAO qualification before the O-4 promotion board had the largest impact: the probability of receiving a RAP on the last LT FITREP was 13.1 percent higher for those with a TAO qualification, early

FITREP performance (EPCTREP) had a highly significant positive effect on LASTLTRP, with a one percent increase in EPCTREP increasing the probability of receiving a RAP by 10.3 percentage points. Other significant variables revealed that minorities were 7 percent less likely to receive a RAP on the last LT FITREP, married with or without children increased the likelihood of receiving a RAP by 8.2 and 10.6 percent, respectively, not attending Department Head School decreased the likelihood by 10 percent, and attaining an EOOW qualification increased the likelihood by 10 percent. The predictive ability of the model in column 2 was good, with a correct prediction ratio of 83.5 percent, and a highly significant Chi-Square of 156.56 indicated a good fit.

c. Heckman Approach

Column 3 of Table VIII displays the logit results after introducing the selectivity bias correction factor (LAMBDA), which accounts for unobserved factors taken from the error term that may effect both the likelihood of receiving an early promotion recommendation on the last LT FITREP and the probability of FFGE selection for each officer. The coefficient estimates and statistical significance for all the explanatory variables were nearly identical to those obtained in column 2. As was the case in the first two performance measure models in Tables VI and VII, both LAMBDA and FFGE were insignificant, indicating that selection bias was not a factor. The insignificance of the correction factor, which again may be attributable to the poor predictive ability of the FFGE selection model, essentially renders the interpretation of the treatment variable (FFGE) meaningless.

d. Barnow Approach

Column 4 of Table VIII displays the logit results after attempting to purge the model of endogeneity that may exist between FFGE selection and receiving an early promotion recommendation on the last LT FITREP, which could bias the FFGE estimate. Instead of using FFGE, the probability of FFGE selection for each officer (PHAT) was used as an instrumental variable in this model specification. Statistically significant variables were the same as those obtained in column 2. As was the case in the previous two performance models, the variable used to measure the impact of FFGE on LASTLTRP and to correct for potential selection bias, PHAT, was insignificant. This indicates that the probabilities of FFGE selection had a negligible impact on receiving a RAP on the last LT FITREP.

V. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions drawn from the empirical analysis of this thesis. The chapter also proposes recommendations for further research into the effects of graduate education on officer performance.

A. CONCLUSIONS

The results from the estimates of the FFGE probit selection model supported the CNO's three criteria for selection into the fully-funded graduate education program. The statistical significance of GPA, math skills, and number of NPS curricula eligible supported the undergraduate academic performance criteria; the statistical significance of percent of early FITREPs receiving an early promotion recommendation supported the greater promotion potential criteria; and the statistical significance of attaining early SWO, EOOW, or TAO qualifications supported the superior professional performance criteria. However, the ability of the model to predict officers with FFGE turned out to be very poor, most likely due to the inadvertent omission of important unobservable factors. Among these are: quota availability, detailer requirements, personal preferences, community pressures, and motivation.

The results of this thesis provided answers to some important questions concerning the effect of fully-funded graduate education on Surface Warfare Officer performance. First, as illustrated in Table VI, Chapter IV, fully-funded graduate education is significantly related to promotion to O-4. Even after holding constant all other possible observable factors that would have an impact on promotion, FFGE remained a highly significant and positive determinant of the probability of promotion. From a promotion standpoint, leaving the warfare environment to attain FFGE appears to be career-enhancing. Although FFGE plays a significant role in promotion, LT FITREP performance and attending Department Head School were more highly significant in explaining promotion to O-4. It is also interesting to note, even though officers technically have no control over it, those who served on CRUDES ships appear to have an advantage over those who never served on a CRUDES ship. This could add some "steam" to claims of institutional bias within the Surface Warfare community.

Secondly, as illustrated in Tables VII and VIII in Chapter IV, fully-funded graduate education has a statistically insignificant impact on receiving early promotion recommendations on LT FITREPs. Although the distribution of officers with and without FFGE by performance measures, displayed in Figure 1 in Chapter I, suggested that FFGE causes better performance on LT FITREPs, when all other observable factors are held constant, FFGE became insignificant in both the percent of LT FITREPs RAP model and the last LT FITREP RAP model.

It should be noted, however, in the percent of LT FITREPs RAP model, that FFGE became insignificant only after the Navy experience variables were added to the model. This implies that both FFGE and Navy experience are, in fact, correlated with receiving a RAP on LT FITREPs, although Navy experience factors carry more weight in determining this performance measure. Consistent with the promotion model, the two FITREP performance models indicated that previous (early) FITREP performance and attending Department Head School were also very important factors in explaining early promotion recommendations. Additionally, although professional qualifications (EOOW, TAO) were also significant in the promotion model, they seemed to have a greater effect on FITREP performance, compared to promotion. From a FITREP performance perspective, in light of the insignificant effect of FFGE on LT FITREP performance, and considering that most of the "observed" LT FITREPs are evaluated after FFGE attainment, it can be concluded that leaving the warfare environment to attain a fully-funded graduate degree neither contributes nor detracts from Surface Warfare career-enhancement, as measured by fitness reports.

Finally, as discussed in Chapter II, the military measures productivity through performance within rank (FITREPs), promotion, and retention. The contention of the theory of human capital investment that formal education increases productivity appears to be supported; the FFGE variable was highly significant in the promotion measure of performance. However, the question of whether graduate education alone accounts for the increased productivity has yet to be answered, due to the inability to completely isolate FFGE from unobserved factors suspected of potential selection bias. Thus, the pay-off to the Navy from its investment in fully-funded graduate education remains unclear, due to the fact that those officers promoted with FFGE are already considered more promotable and may have been promoted even if they had not attained FFGE (i.e., selection bias). This leads us to the results obtained from the two approaches used to determine and correct for potential selection bias associated with FFGE selection.

Given the statistical significance of the observed factors included in the selection model, one could conclude that selection for FFGE is not random and that selection bias would be inevitable, causing the coefficient of the FFGE variable to be overestimated in the performance models. However, both of the techniques used to determine and correct for potential selection bias (the Heckman and Barnow approaches) found little evidence that selectivity was a problem. Although the confidence in the results of these selection bias models is much degraded, due to the poor predictive ability of the FFGE selection probit, the selection correction factor (LAMBDA), from the Heckman approach, and the probability of selection for FFGE (PHAT), from the Barnow approach, both had statistically insignificant effects in the three performance models. These two techniques attempted to account for the possibility that officers chosen for FFGE were better performers, more highly motivated, with a higher desire for achievement and, thus, more promotable. These techniques were unable to capture these unobservables, hence, the insignificant effect of selection bias.

As discussed in the section on selectivity bias in Chapter II, the ability to detect and correct for selection bias is highly dependent on an accurate specification of the selection model. It is reasonable to conclude that the FFGE selection model adequately captured the important observable (measurable) factors in the selection process; however, the inability to account for unmeasurable factors such as billet availability, detailing priorities, personal preferences, and individual career intentions may have seriously downgraded the accuracy of the selection model to fully capture the Navy's actual FFGE selection process. Again, the selection model was only able to predict 6.7 percent of those actually with FFGE. In light of this fact, one should not impulsively conclude from this thesis that FFGE has no value added to SWO performance. Consequently, the issue of whether the increase in productivity is attributable to fully-funded graduate education alone, observable factors, and/or unobservable factors requires further research.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

Until this thesis, no known attempt has been made to model selection for fully-funded graduate education. The FFGE selection model in this thesis sufficiently captures observed (measurable) factors that significantly impact selection for FFGE, but apparently do not contribute to any bias that may be associated with those officers selected for FFGE. Further research on the FFGE selection process is recommended, for it is possible that selection bias may lie within factors unavailable in the data set used for this thesis. The data for this study classified selection for FFGE only if the officer had attained a fully-funded graduate degree. The population was all Surface Warfare Officers regardless of whether they were qualified for graduate education, or were given the option to pursue it. Individual preferences is an important factor in FFGE selection and may be captured by obtaining data on all officers who qualify for FFGE and on those who are offered it. This approach would involve analyzing individual decisions to accept graduate education among the population of those qualified who were offered the option to attend graduate education. Timing of one's transfer may also be significant in the selection process -- FFGE may not be available or offered to an individual who is transferring in the middle or right after the beginning of an academic quarter or semester. Although difficult, accounting for these factors in the selection process, which can also be applied to other Navy communities, should be the goal of future research.

This thesis utilized data that provided career "snapshots" of individual officers at the O-3 and O-4 promotion board points. Retrospective data were then assembled on these officers. A longitudinal analysis of cohort data would reveal a great deal more information on performance of individual officers by enabling the researcher to follow them through their career.

Subspecialty codes are acquired in conjunction with the attainment of a fully-funded graduate degree. It would be fruitful to graduate education policy makers to incorporate technical and nontechnical subspecialty degrees in the performance analysis to determine if there are differences across subspecialty types. This could indicate which subspecialties are more cost effective to the Navy.

The bivariate analysis in Table IV of Chapter IV revealed that minorities with FFGE failed to promote as favorably as whites with FFGE, even though they maintained higher LT FITREP RAP percentages. Although the multivariate analysis found that minorities were statistically insignificant, in light of the current emphasis on minority issues within the military, it is recommended that minority promotion rates be explored further.

Only one community (Surface Warfare) was chosen for analysis in this thesis. Due to the differences in how different communities evaluate officers, sharp differences in career paths between communities, and the lack of comparable Navy experience factors, it is recommended that future research efforts analyze the effect of fully-funded graduate education on other communities (remaining URL, GURL, RL, and Staff Corps) utilizing identical performance measures and modeling techniques utilized in this thesis.

APPENDIX

As discussed at the end of Chapter III, the decision to leave the service at the completion of one's initial tour of obligation represents an additional level of selection, preceding FFGE selection, that may effect the outcome of the three performance models. That is, the sample of officers considered for promotion to O-4 is truncated since they represent only those officers remaining in the Navy through the O-4 promotion point. Hence, assuming that both levels of selection are independent from one another, a multiple selection approach using correction factors for both separation and fully-funded graduate education is illustrated below.[19]

Table IX displays the results of a probit model used to explain separation behavior, where SEP=1 if the officer left the Navy voluntarily before the O-4 board, else SEP=0. The interservice separation code (ISC) was used to identify voluntary leavers, all other leavers and those leaving the SWO community but remaining in the Navy were omitted from the

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[19] Greene's econometric software, LIMDEP, addresses dual selection with the specification of a bivariate probit with selection model. From this procedure, a term called RHO is obtained and its statistical significance indicates whether the two selection processes are interdependent (RHO significant), or independent (RHO insignificant). However, due to the nature of the selection process in this study (the sample being restricted to "stayers" only), the two levels of selection were treated as independent. [Ref. 15]

analysis in an effort to capture true separation behavior. Table X displays the results of each performance measure after applying a dual selection approach using the Heckman technique, where LAMBDA1 represents the selection correction factor obtained from the separation probit and LAMBDA2 represents the selection correction factor obtained from the FFGE selection probit displayed in Table V, Chapter IV.

As Table IX shows, the attributes significantly contributing to the likelihood of separation prior to the O-4 promotion board were: higher undergraduate GPA's; OCS commissioned officers, especially those attending a less competitive college, compared to USNA graduates; and never having served on a CRUDES ship.

On the other hand, attributes significantly contributing to the likelihood of remaining in the Navy were: receiving an early promotion recommendation on early FITREPs; commissioned through ROTC, compared to USNA; being female; age (where a one year increase represented a 13 percent decrease in the probability of separating); married with or without children and divorced with children (compared to being single); nuclear officers were 10.6 percent less likely to separate; and those attaining a SWO qualification prior to promotion to O-3 were 6.2 percent less likely to separate.

TABLE IX. PROBIT ESTIMATES OF THE "SEPARATION" MODEL.[1]

VARIABLE	ESTIMATED COEFFICIENT[2]	CHANGE IN PROBABILITY[3]
EPCTREP	-.305 (-4.89)[1] **	-.102
GPA	.090 (2.74) **	.030
HISLROTC	-.215 (-2.53) **	-.072
HISELOCS	.960 (10.24) **	.322
LOSLROTC	-.191 (-1.89)	-.064
LOSELOCS	1.34 (14.30) **	.448
NESEP	-.557 (-.696)	-.187
FEMALE	-1.78 (-8.12) **	-.598
MINORITY	-.026 (-.239)	-.009
AGENOW	-.387 (-27.99) **	-.130
MARONLY	-.306 (-4.50) **	-.103
MARCHILD	-1.10 (-15.17) **	-.369
DIVCHILD	-.612 (-2.78) **	-.205
NUC	-.315 (-2.79) **	-.106
NOCOMBAT	1.14 (13.44) **	.383
EARSWO	-.185 (-3.05) **	-.062
EAREOOW	-.089 (-.905)	-.030
EARTAO	-.480 (-1.56)	-.161
INTERCEPT	11.88 (27.85)	----
CHI-SQUARE LOG LIKELIHOOD	2530.00**	
PREDICTION RATIO[4]	87.2%	

[1] Where N=3,787 (1,477 stayed, 2,310 separated).
[2] t-statistic in parentheses measures significance of coefficient.
[3] Calculated by multiplying the estimated coefficient by the density of the standard normal distribution function corresponding to the particular probability level, as given by the cumulative normal distribution function for which the change is being evaluated. [Ref. 19]
[4] Ratio of correct predictions over total number of observations.

<u>Note</u>: 82.1% of those actually staying were correctly predicted, 90.4% of those actually separating were predicted correctly. The model also predicted that 62.2% of the sample would separate, while 61% actually did.

* Significant at the .05 level.
** Significant at the .01 level.

In terms of the fit of the model, the chi-square log likelihood statistic was highly significant and the model correctly predicted 82.1 percent of those actually staying and 90.4 percent of those actually separating for a combined prediction ratio of 87.2 percent. Combined with this extremely high prediction ratio for those separating (relative to the 6.7 percent obtained in the FFGE selection model), and the fact that 13 of the 18 variables used to explain separation behavior were highly significant (at least to the .01 level), implies that the specification of the model is accurate in capturing separation behavior and may be evaluated as reliable.

TABLE X. ESTIMATES WITH THE DUAL-SELECTION HECKMAN TECHNIQUE FOR EACH PERFORMANCE MEASURE.

VARIABLES	HECKMAN TECHNIQUE [1]		
	PROMOTE	LPCTREP	LASTLTRP
INTERCEPT	-1.34 (-.450) ----	1.15 (3.50) ----	-.056 (-.022) ----
EPCTREP	1.08 (3.86)** [.104]	.135 (5.23)** ----	.763 (3.53)** [.106]
LPCTREP	2.15 (10.39)** [.207]	---- ---- ----	---- ---- ----
GPA	.067 (.607) [.007]	.015 (1.26) ----	-.016 (-.180) [-.002]
HISLROTC	.083 (.278) [.008]	-.017 (-.558) ----	-.056 (-.239) [-.008]
HISELOCS	.088 (.217) [.009]	.007 (.154) ----	-.477 (-1.42) [-.066]

VARIABLES	HECKMAN TECHNIQUE [1]		
	PROMOTE	LPCTREP	LASTLTRP
LOSLROTC	-.304 (-.962) [-.029]	-.066 (-2.02)* ----	-.227 (-.879) [-.031]
LOSELOCS	-.071 (-.155) [-.007]	.008 (.173) ----	-.461 (-1.21) [-.064]
NESEP	-.211 (-.154) [-.020]	-.017 (-.095) ----	10.03 (.064) [1.00]
FEMALE	3.58 (3.29)** [.345]	.072 (.735) ----	.509 (.728) [.070]
MINORITY	.183 (.592) [.018]	-.050 (-1.41) ----	-.493 (-1.99)* [-.068]
AGENOW	-.017 (-.204) [-.002]	-.014 (-1.57) ----	.023 (.329) [.003]
MARONLY	.482 (1.72) [.046]	.014 (.455) ----	.809 (3.46)** [.112]
MARCHILD	.923 (2.46)** [.089]	-.004 (-.096) ----	.750 (2.45)** [.104]
DIVCHILD	.654 (.932) [.063]	-.153 (-2.11)* ----	-.091 (-.181) [-.013]
NUC	2.48 (4.17)** [.239]	.072 (1.73) ----	.216 (.623) [.030]
NOCOMBAT	-1.61 (-3.41)** [-.155]	-.056 (-1.01) ----	-.362 (-.929) [-.050]
NODEPHD	-1.81 (-9.37)** [-.174]	-.135 (-5.70)** ----	-.710 (-4.30)** [-.098]
EARSWO	-.106 (-.496) [-.010]	.117 (5.30)** ----	-.032 (-.185) [-.004]
EOOWQUAL	.642 (3.21)** [.062]	.092 (4.58)** ----	.703 (4.20)** [.097]

VARIABLES	HECKMAN TECHNIQUE [1]		
	PROMOTE	LPCTREP	LASTLTRP
TAOQUAL	.730 (3.04)** [.070]	.061 (2.81)** ----	.926 (4.48)** [.128]
FYSB85	2.20 (4.28)** [.212]	---- ---- ----	---- ---- ----
FYSB86	1.17 (3.71)** [.113]	---- ---- ----	---- ---- ----
FYSB87	1.25 (4.07)** [.120]	---- ---- ----	---- ---- ----
FYSB88	.223 (.705) [.022]	---- ---- ----	---- ---- ----
FYSB89	.411 (1.50) [.040]	---- ---- ----	---- ---- ----
FFGE	1.15 (.841) [.111]	-.118 (-1.07) ----	-.116 (-.122) [-.016]
LAMBDA1 [2]	-.615 (-1.09) [-.060]	.066 (1.04) ----	-.324 (-.694) [-.045]
LAMBDA2 [3]	-.142 (-.185) [-.014]	.083 (1.30) ----	-.029 (-.053) [-.004]
CHI-SQUARED LL	579.01**	----	157.05**
PREDICTION RATIO	89.2%	----	83.4%
ADJUSTED R-SQUARED	----	.157	----
F-STATISTIC	----	13.45**	----

[1] First figure is coefficient estimate, the t-statistic is in parentheses, and the change in the probability associated with a one unit increase in the explanatory variable obtained by multiplying the coefficient by Px(1-P) is in brackets, where P is the percent of observations predicted correctly.

[2] LAMBDA1 is the selection bias correction factor obtained from the separation probit.

[3] LAMBDA2 is the selection bias correction factor obtained from the FFGE selection probit.

* Significant at the .05 level.

** Significant at the .01 level.

The results obtained for each performance measure through the dual selection Heckman approach, displayed in Table X, were very similar to those obtained using the single selection Heckman approach (see Tables VI, VII, and VIII, Chapter IV). The coefficients for FFGE and the selection correction factor (LAMBDA and LAMBDA2), obtained from the FFGE selection probit, in both the dual and single selection Heckman approaches for each performance measure were virtually identical and insignificant. Additionally, Table X revealed that the selection correction factor (LAMBDA1), obtained from the separation probit, was insignificant in all three performance models. The fact that the coefficient for FFGE remained constant and the separation selection correction factor was insignificant implies that accounting for the additional level of selection (separation), has no effect on the impact of FFGE on performance. As discussed earlier, the ability to detect and correct for selection bias is highly dependent on the correct specification of the selection probit. Consequently, these results are notable due to the reliability of the separation probit.

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