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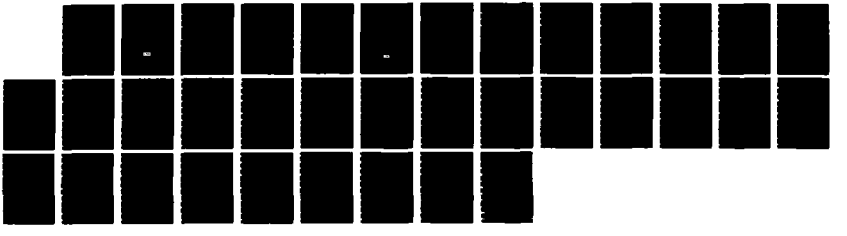

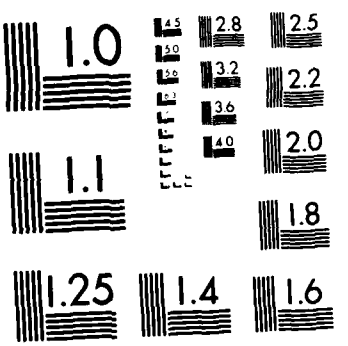

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RESEARCH MEMORANDUM

MANNING THE 600-SHIP NAVY: ANALYSIS OF FORCE STRUCTURE AND COMPENSATION OPTIONS FOR NAVY PROGRAM PLANNING

Bruce N. Angier

N00014-83-C-0725

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MANNING THE 600-SHIP NAVY: ANALYSIS OF FORCE STRUCTURE AND COMPENSATION OPTIONS FOR NAVY PROGRAM PLANNING

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INTRODUCTION

The result of the 1980 U.S. presidential election was perceived as a mandate to increase the resources devoted to national security. One of the primary strategic initiatives undertaken to fulfill this commitment has been an effort to develop a 600-ship Navy, an approximately 25-percent increase in the number of surface combatants and support vessels. A critical factor in this growth will be the ability of the Navy to attract and retain the quantity and quality of enlisted personnel with the requisite skills to make this force effective.

Economic theory can provide a framework to analyze these issues and a set of hypotheses to be examined. Econometric methods can test the significance of these hypotheses and estimate the direction and size of their effects. Knowledge of these effects can then be used to evaluate existing policy options as well as to aid in the development of different policies.[1]

This paper describes how economic analyses done at CNA[2] over the last 5 years were used to describe and evaluate policy options in the Manpower, Personnel and Training portion of the Navy's Fiscal Planning and Programming process for 1986-1989. It consists of three sections: (1) a short description of the Navy's personnel system and other constraints within which policies were evaluated; (2) an evaluation of force structure and compensation options; and (3) a description of the models used to estimate the parameters for policy evaluation. The basic conclusion is that the 600-ship Navy can be manned by personnel with the requisite skills and experience given additional targeted compensation.

INSTITUTIONAL SETTING

The Programming Process

Two to three years before the year a budget is to be executed, the Navy takes the basic strategic posture in the Defense Guidance, compares it to

1. For a relatively complete and accessible survey of these manpower supply and demand topics, see [1].
2. Similar research for other services has been done at Rand. Examples of this work are cited here.

existing inventories and unexecuted programs, analyzes feasible methods of approaching these overarching goals, and develops the official service statement of the program (POM or Program Objectives Memorandum) to be implemented in that budget. In the last quarter of calendar 1983, CNA gave significant analytic support to the Manpower, Personnel and Training (MPT) portion of this process, which results in the MPT CPAM (Chief of Naval Operations Program Analysis Memorandum) that supports the POM.

There were six main issues in the POM-86 MPT CPAM. CNA gave analytic support to five. The two issues addressed here are the options and costs to: (1) meet the desired FY 1989 inventory of enlisted personnel and the aggregate experience mix, and (2) meet the desired manning levels in specific ratings of particular importance to the Navy.

The Navy Enlisted Personnel System

Since these issues involve questions about manpower supply, it is important to understand a few basics about the Navy enlisted personnel system and the way these personnel are compensated.

The system is a closed one. Almost all recruits enter with no technical training; then the Navy trains them to its standards. That training is supplied both formally and informally over a career. Formal training tends to be front loaded, though equipment-specific training occurs throughout a career. Informal training comes through experience.

There are almost 100 separate occupations (called ratings), some with several subspecialties. The cost of even the initial formal training varies widely, ranging from $3,000 to $50,000, with an average of about $11,000.

The compensation system is an amalgam of wages, in-kind benefits (and their associated tax advantages), compensation for arduous duty, a non-contributory pension system vesting at 20 years service, and bonuses for reenlisting. With the exception of bonuses, these pay categories are inflexible with respect to the civilian opportunities of the individuals. For example, everyone at the same rank and number of years experience receives the same base pay. Also, the cost of some of these compensation schemes is unrelated to the rank and experience of the individual. For example, the effective value of the entitlement to in-kind benefits for food and quarters depends in part on marital status.

As of December 1983, the size of the Selective Reenlistment Bonus (SRB) was a multiplicative product of three factors: monthly base pay at the time of reenlistment, a "bonus multiple" which ranges from zero to six in increments of one half, and the number of years of reenlistment. It is circumscribed by three constraints. First, with only a few exceptions, reenlistments must increase the service obligation by at least 3 years but no more than 6 years. Second, bonus multiples must be between zero and six, and third, the total bonus is capped at $16,000 for most potential reenlistees.[1] The fact that increases in service obligation of less than 3 years are not compensated by a bonus can interject complications into the modeling process. These complications will be discussed below.

Reenlistments average about 4 years. Annual continuation rates for those not at a reenlistment point in length-of-service (LOS) cells 1-4 are in the range of 90-93 percent, while those in LOS 5-30 are 95 percent or more. Survival rates for those at the 4-, 8-, 12-, and 16-year reenlistment points during 1983 were approximately 45, 60, 85, and 95 percent.

FORCE STRUCTURE AND COMPENSATION OPTIONS

CNA was asked to suggest compensation strategies to help the Navy attain different desired force structures. These force structures, and the compensation packages developed, are labeled "all-Navy," "sea-intensive, mission-critical," and "material-readiness-related, sea-intensive, mission-critical." The alternatives examined are described below. The all-Navy strategy included issues such as: What will the mix of first-termers and careerists be under various pay and economic scenarios? Are these force mixes reasonable? Which scenarios embody the most likely economic assumptions? And what additional compensation would be required to achieve both total endstrength and the desired first-term/career force mix under the more realistic scenarios?

There were strong suspicions that this analysis would not yield acceptable results, and in fact it did not. The second strategy focused on the compensation necessary to meet desired endstrength and experience mix for the

1. After this analysis was completed, the bonus cap was raised to $20,000 for all reenlistees, and $30,000 for up to 10 percent of all reenlistment contracts.

sea-intensive, mission-critical ratings – those that spend relatively long periods of time at sea and work in jobs related directly to the ability of ships to steam and fight. Twenty ratings encompassing a little more than one-third of the Navy's enlisted force fall in this category. Identification of these ratings was an effort to inject some aspects of demand for various labor types into the analysis.[1]

The third compensation strategy was based on selecting 5 of these 20 ratings whose manning levels have been determined to be systematically related to downtime on the equipment that they operate or maintain. These material-readiness-related, mission-critical, sea-intensive ratings were designated as a group whose manning levels had potentially large, measurable, marginal effects on readiness.

The main computer-implemented projection model used in the analysis was the Annualized Cost of Leaving (ACOL) model developed at CNA. It projects reenlistment behavior of Navy enlisted personnel in the aggregate only. Accessions are determined as the residual necessary to meet end-strength. The inputs to this model are existing personnel inventories, economic and policy scenarios, and elasticities that capture the effects on the inventories of the variables specified in the scenarios.[2] Calculations for individual occupations (ratings) were done manually.

Enlistment supply is projected using a simplified projection model based on the estimated effects of pay, number of recruiters, unemployment, other government programs, and demographic factors. This model is maintained by the Naval Recruiting Command. It is based upon the more sophisticated CNA accession supply model discussed below, which is more completely described in [11].

1. Given the constraints of this analysis, there was no rigorous consideration of the factors determining requirements (demand). However, there is ongoing work at CNA on the relative value of enlisted personnel based on experience. References [2] and [3] are representative of these efforts. Other recent works include [4]. Some effort has been made to incorporate this work into the analysis of accession-retention tradeoffs (e.g., [5]).

2. A more detailed explanation of the projection portion of this model is contained in [6]. Tests of its accuracy are described in [7]. Different models with a similar purpose are discussed in [8,9,10]. The construction and estimation of these elasticities are discussed below.

First-Term/Career Force Mix Under Various Scenarios

The inventory of enlisted personnel at the end of FY 1983 and the FY 1989 inventory goal are presented in table 1.

TABLE 1

ENLISTED PERSONNEL INVENTORIES
(In thousands)

	Actual in Sep 1983	Desired in FY 1989
All Navy	503	548
First term (LOS 1-4)	280	281
Career (LOS 5-30)	223	267

The client for this work (Op-914) presented CNA with several economic scenarios based on variations in relative military pay and allowances, different levels of Selective Reenlistment Bonuses (SRBs), modifications to the military retirement system, and different levels of the total unemployment rate as presented in tables 2 through 5.

The ACOL model produced the FY 1989 inventories shown in table 6. The ACOL force projections of career endstrength over time, based on these various scenarios, are summarized in figure 1. The major results are that, relative to the base case: (1) the Navy gets caught short in the inventory of experienced personnel and (2) it must make up the shortfall with less experienced, less effective personnel, or operate both shorthanded and undertrained.

Meeting Endstrength by Accessions Rather Than Reenlistments

After a discussion between CNA and Navy analysts, the "Real4" case was assumed to embody the economic and pay assumptions most likely to occur. The cost difference between meeting endstrength by accessions versus the extra SRB dollars that would be required to develop the 267,000 career force through retention under the Real4 scenario was calculated. In the Real4 case relative to the base case, the 548,000 total force is created by recruiting more people. The number of extra accessions needed rises from 4,200 in FY 1986 to 12,100 in FY 1989, and averages 8,300 per year.[1] The costs of

1. The client asked CNA to use averages and not to discount costs for presentational purposes. As long as the time streams of various options are similar, relative rankings are not affected.

getting such individuals enlisted and minimally qualified are presented in table 7. The total is $134 million.

TABLE 2

POM SCENARIOS

Factors	Cases				
	Optimistic	Base	RealC	Real4	Pessimistic
Base pay					
Pay 1984	3%	Comp.[a]	3%	3%	3%
1985	11.1%	Comp.[a]	4%	4%	4%
1986-89	Comp.[a]	Comp.[a]	Comp.[a]	4%	4%
Selective Reenlistment Bonus	Levels	Levels	Budget 1984 & 1985, then levels	Levels	Budget (-25%)
	Lump sum?[b]	Yes	No	No	No No
Unemployment (table 4)	CBO-High	OMB	OMB	OMB	CBO-Low
Retirement	Current	Current	COLA caps thru 1986[c]	COLA caps thru 1986[c]	COLA caps permanent[c]
Variable housing allowance[d]	Regains lost value	CPI indexed	CPI indexed	CPI indexed	BAQ indexed

a. Comparability (Comp.) assumes that military and civilian pay will grow by the same percentage (see table 3).

b. Over the past 7 years, bonuses have been paid in three different ways: in annual installments; in a lump sum; and half as a lump sum, with the other half divided equally over the remaining years of the enlistment. "Yes" means lump sum, "No" means half now, half later. Annual installments were not considered as a policy option.

c. COLA caps are 50 percent of the calculated cost-of-living adjustment.

d. The variable housing allowance provides extra compensation to individuals in "high-cost-of-living" areas.

TABLE 3

OMB FORECAST OF CIVILIAN PAY GROWTH

FY 1983 - 9.5%
1984 - 6.3
1985 - 5.6
1986 - 5.8
1987 - 5.8
1988 - 5.6
1989 - 5.5
1990 - 5.5

TABLE 4

FORECASTED UNEMPLOYMENT RATES

	CBO "High"	OMB	CBO "Low"
FY 1983	10.2%	10.2%	10.2%
1984	9.8	9.2	8.5
1985	9.0	8.3	7.7
1986	8.4	7.7	7.0
1987	8.0	7.1	6.4
1988	7.5	6.4	6.0
1989	7.5	6.4	6.0
1990	7.5	6.4	6.0

TABLE 5

SRB TERMINOLOGY

SRB "Levels" - The level of new SRB payments requested by the Navy for FY 1984 ($170.7 million)

SRB "Budget" - The actual level of new payments in place for FY 1984 ($133.6 million)

TABLE 6

PERSONNEL INVENTORIES PRODUCED WITH ACOL MODEL
(In thousands)

	FY 1983 inventory	FY 1989 inventories				
		Base	Optimistic	RealC	Real4	Pessimistic
Total force	503	548	547	548	548	548
LOS 5-30	223	267	289	257	239	214
LOS 1-4	280	281	258	291	309	334
LOS 1	76	81	72	84	93	101

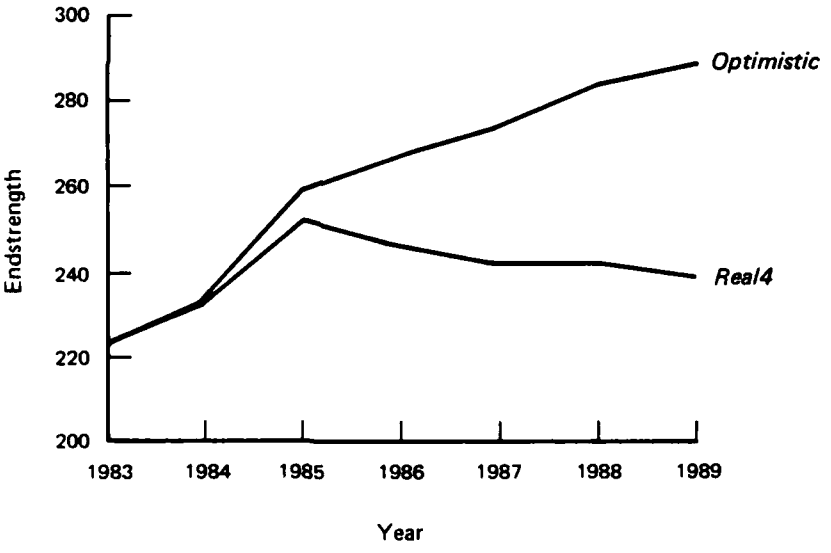

FIG. 1: ACOL FORCE PROJECTIONS

TABLE 7

ACCESSION AND TRAINING COSTS FOR A STANDARD SCHOOLING MIX
(Average cost FY 1985-1989 in thousands of dollars)

	A-School	Apprenticeship
Recruiting cost	$5.4	$0.3
Enlistment bonus[a]	.2	–
Recruit training	3.4	3.4
Apprenticeship training	–	3.4
Initial training[b]	11.0	–
	$20.0	$7.1
70 percent A-school	$14.00	
30 percent apprenticeship	2.13	
	$16.13	
Number of accessions	x 8.3	
Total cost	$133.9 million	

Source: [5] unless noted below.

a. 1983 enlistment bonuses totalled $10.6 million (according to Op-136D), inflated to 1987-88 dollars and divided by number of A-school attendees.
b. Modification of [12] by an estimate of the cost of additional C-school training.

Using reenlistment bonuses alone, the Navy could retain enough people to make up the differences between the Real4 case and the base-case inventories. The calculations to arrive at this cost are shown in table 8. The total is $146 million.

As can be seen, the recruiting option is slightly less expensive than paying additional reenlistment bonuses. However, when these options were presented to the Navy officials preparing the CPAM, it was clear that the unquantified benefits of a trained, experienced force were far more important

than the cost difference.[1] Their opinion is strongly supported by such studies as [4, 5, 12, 15].

TABLE 8

ADDITIONAL BONUS NECESSARY UNDER REAL4 SCENARIO TO ACHIEVE BASE-CASE ENDSTRENGTH AND FIRST-TERM/CAREER FORCE MIX

	Reenlistment points		
	1st	2nd	3rd
Percent decrease in retention rate from base case to Real4 case	25%	14%	6%
Zone pay elasticity	1.86[a]	2.20[a]	0.35[b]
Required percentage pay changes	13.4%	6.3%	17.1%
Regular Military Compensation[c] ($000)	16.6	18.9	22.2
Pay change ($000)	2.23	1.18	3.80
Number of reenlistments FY 85-89[d]	35.7	21.6	10.8
Additional zone cost (millions)	79.60	25.49	41.04
Total			$146.13

a. Source: [13].
b. Source: [14].
c. E-4 greater than 4, E-5 greater than 8, and E-6 greater than 12, respectively, plus existing bonus.
d. ACOL run averages from length-of-service cells 5, 9, and 14.

1. As a point of reference, the cheapest way to meet endstrength is to enlist people who are not eligible for A-schools because of low aptitude and education. The cost of this policy is shown in table 9. This approach was considered totally unacceptable. The Navy would not train these individuals in the skills necessary to man the fleet, and they would have trouble learning the skills on the job.

However, there are significant problems with this policy. Although it would enable the Navy to meet both endstrength and first-term/career force goals, the mix of skills in this force would not match the "requirements" used to construct the original aggregates. There are three reasons for this mismatch. First, the Navy has historically tended towards overmanning in some ratings and undermanning in others. In large part, this is the result of a relatively equal compensation structure being applied to occupations with very different civilian substitutability and nonpecuniary characteristics. Second, the aggregate elasticity used in the calculations is a weighted average of the pay elasticities of different occupational groups. The marginal effect of increased pay is different between groups and tends to exacerbate already existing imbalances (see table 10). Third, these undermanned ratings have tended to be the "steam or fight" ratings, the ratings the Navy considers most mission critical.

TABLE 9

COST OF LOW-QUALITY ACCESSIONS
(Average cost, FY 1985-89, in thousands of dollars)

	Costs[a]
Recruiting cost	.3
Recruit training	3.4
Apprenticeship training	3.4
	7.1
Number of accessions[b] (000)	x10.0
Total cost	$71.0 million

a. Source: [12].

b. An estimate of the number of non-school-eligible accessions necessary to meet endstrength. For information on the survival of these individuals in the Navy, see [16].

Therefore, CNA was asked to examine two subsets of Navy ratings: first, a group of 20 "mission-critical, sea-intensive" ratings; second, a subset of that group, 5 "material-readiness-related, mission-critical, sea-intensive" ratings.

These 20 ratings appear only in the Electronics and Nonelectronics categories in table 10. They encompass approximately one-third of Navy enlisted personnel in the career force.

TABLE 10

PAY ELASTICITIES AND SHORTAGES

Occupational category	Pay elasticities		
	1st term[a]	2nd term[a]	3rd term[b]
Nonelectronics	1.89	0.94	.49
Electronics	2.02	2.65	.46
Aviation maintenance	2.38	2.98	.22
Ship/aircraft support	1.86	2.52	.27
Healthcare	1.12	1.35	.25
Logistics	1.67	3.78	.19
Construction	2.72	–	.34
Cryptology	1.85	1.28	.31
Administration/Media	1.78	2.50	.18
Weighted average	1.86	2.20	.35

a. Source: [13].
b. Source: [14].

Critical Ratings

This analysis of critical ratings required a two-part procedure. The first was exactly the same as that described for the aggregate case. The second part was the addition (or in a few cases the subtraction) of enough bonus dollars to retain enlisted personnel to meet requirements. The results of this procedure are shown in table 11. The fact that the cost of meeting requirements in these 20 ratings is 85 percent of the cost of meeting total endstrength requirements is mainly a function of filling already existing shortfalls in these rating inventories, though the low pay elasticity for nonelectronics second termers is in part responsible.

There are several advantages to this strategy compared with the earlier approach of meeting aggregate goals only. First, it achieves the "required" inventories for these 20 (or 5) ratings. Second, it concentrates resources on ratings that Navy decision-makers feel are more important in producing overall readiness, at least on the margin. Third, by concentrating bonus dollars on ratings that are undermanned, it may be more palatable to Congress.

TABLE 11

SRB INCREASE FOR CRITICAL RATINGS

		Average bonus level (no cap)		
Group	Aggregate cost	1st term	2nd term	3rd term
20 ratings	$125 million	8.1	7.5	3.3
5 ratings	33 million	8.3	7.2	3.3

However, the suggested SRB increase has two disadvantages. The first is that it could not be implemented under the then-current restrictions on bonus levels and ceilings on total bonus payments. As shown in table 11, the average bonus multiples for zones A and B are above the limit of six. For a 4-year reenlistment, the implied total bonus is approximately $30,000, almost twice the $16,000 maximum. Simply stated, at that time the Navy could not target bonuses to the extent that the CNA analysis did because the law prevented it. The second disadvantage is that, even within those mandated constraints, Congress tends to cut the funds requested for bonus programs. In an effort to work around these constraints, CNA was asked to determine the effects of achieving endstrength in the 20 critical ratings through increased sea pay for all ratings.[1]

The basic course and results of this analysis can be quickly described. The 20 ratings, though a third of the enlisted career force, make up approximately half of the seagoing jobs. Individuals in these 20 ratings spend two-thirds of their time at sea, while individuals in the other ratings average

1. The analysis ignored the effect of such a pay change on the individual's willingness to serve at sea versus on shore.

approximately 40 percent of their time at sea. Therefore, obtaining Congressional permission to increase sea pay for all ratings enough to fully man the 20 critical ratings would double the $125 million cost estimated earlier. This increased cost could be partly offset by cutting SRB payments for all those other ratings who were receiving them.[1] Such a cut in these payments would bring the cost down from $250 million to $200 million. However, the Navy would still be paying $75 million per year of additional pay to individuals in ratings (which originally had a zero bonus level) that do not need extra reenlistment incentives.

The Value of This Work to CNA

In many ways, this sort of analysis is difficult. Deadlines are short, so minimally substantiated assumptions must be made in order to produce timely results. Due to such deadlines, it is often not possible to redirect requests into areas the analyst sees as more fruitful, or at least towards more tractable analytic issues.

On the plus side, this kind of quick-response analysis generates immediate Navy feedback. It also gives the CNA analyst access to Navy personnel with the expertise to guide in evaluating the less quantifiable aspects of suggested policy options. Such guidance sometimes redirects analytical efforts towards more important questions.

Finally, participation in these sort of activities is extremely valuable in helping to set CNA's research agenda. Ongoing work that is either a direct follow-on to CNA's participation in POM-86, or whose importance was made more evident, includes

- Relating quantity, quality, and skills in the enlisted personnel inventory to readiness measures
- Updating retention elasticities to determine whether they changed in the 1981-83 period

1. This is not a recommendation, only a part of the analysis of this option.

- Studying modifications to the current sea-pay system to better target compensation for the arduous nature of sea duty in particular ratings that are required to spend more time at sea

- Embedding the results of our accession/retention research in simple, flexible force-projection models for use by analysts and policy-makers.

MODELS

Retention Supply Analysis[1]

We assume that individuals reaching the end of an enlistment term will evaluate their net advantage of leaving the service, as opposed to staying j periods, where $j = 1, \ldots, h$. This net advantage is made up of pecuniary and nonpecuniary factors. The individual will stay in the military if the net advantage of military service exceeds the net advantage of leaving.

Most of the retention analysis done at CNA rearranges this relationship from a simple comparison based on the net advantage of military versus civilian occupations to a simple comparison based on net pecuniary and net nonpecuniary factors. This comparison is done both to segregate pays (that is, more easily measurable attributes) from tastes (less easily measurable attributes), and also because military pay levels and raises are often discussed relative to civilian pay. Therefore, the pecuniary factors are combined into an "annualized cost of leaving" (A_j). For the purposes of exposition, the nonpecuniary factors are combined into a "net annual monetized taste for civilian life" (T). The individual will leave the military if there is no time horizon over which the net benefits of the military (the maximum A_j) outweigh the net taste for civilian life, and will stay otherwise. Formally, if

h = maximum allowable future periods of service

L = life expectancy

M_j = expected military pay in year $j = 1, \ldots, h$

1. This model structure is most closely related to [17]. For a rigorous discussion of many of these issues, see [18]. Similar work is discussed in [8, 9, 19, 20].

R_{ij} = pension that the individual will receive if he or she serves j years, where $i = (j + 1), \ldots, L$ and L is life expectancy

C_{io} = future civilian earnings stream for leaving immediately, $i = 1, \ldots, L$

C_{ij} = future civilian earnings stream for leaving after j years, $i = (j + 1), \ldots, L$

r = individual's discount rate

$PV_i = \frac{1}{(1 - r)^i}$ the present value of a dollar at year $i = 1, \ldots, L$

T_c = annual monetary equivalent of an individual's taste for civilian life

T_m = annual monetary equivalent of an individual's taste for military life

$T = T_c - T_m$ = the net annual monetized taste for civilian life

D_k = difference between the two pay streams (military minus civilian) for the kth year

A_k = annualized cost of leaving in year k

A_{max} = maximum value of A_k, $k = .1, \ldots, h$

then the utility of remaining in the military exactly k years exceeds that of leaving immediately if

$$\sum_{i=1}^{k} (M_i + T_m) PV_i + \sum_{i=(k+1)}^{L} (R_{ik} + C_{ik} + T_c) PV_i$$

$$> \sum_{i=1}^{L} (C_{io} + T_c) PV_i$$

Collecting monetary factors and tastes, this condition is

$$\sum_{i=1}^{k} M_i PV_i + \sum_{i=1}^{L} (R_{ik} + C_{ik}) PV_i - \sum_{i=1}^{L} C_{io} PV_i$$

$$\rangle \sum_{i=1}^{k} (T_c - T_m) PV_i \ .$$

Using the notation developed above

$$D_k \rangle T \sum_{i=1}^{k} PV_i \ ,$$

and dividing by $\sum_{i=1}^{k} PV_i$ yields

$$A_k = \frac{D_k}{\sum_{i=1}^{k} PV_i} \rangle T \ .$$

For a given time horizon h, the individual will stay if at least one A_k, $k = 1, \ldots, h$, is greater than T and will leave otherwise.[1] Therefore the critical A_k is the maximum of A_k. If it is greater than T, the individual stays; if not, he leaves.

1. Modeling the correct time horizon is not a trivial problem. Fortunately, estimated individual discount rates tend to give bounds for individuals at different reenlistment points. (See [21, 22].)

The connection between this model and a general reenlistment supply function is direct. If the annual monetized net taste for civilian life (T) for any given group of individuals has a distribution while there is a maximum A_k, call it A_{max}, then the retention rate is

$$r = P_r(A_{max})\,T) \int_{A_{max}}^{\infty} f(T)\,dT \ .$$

The above formulation assumes that future events are known with certainty. This assumption results in a loss of generality, since the addition of transitory disturbance both better describes our intuition about predicting the future and turns out to allow a retention function to be derived from the model.[1] However, these benefits come at the cost of increased complexity of the analytic and econometric specifications, as well as stronger data requirements (cohort rather than cross-sectional data).

Also, some analysts assert that the model is constrained to be a steady-state model. Given the wide swings in compensation policy that have characterized the AVF period, this constraint would mitigate against the more complicated model.[2]

The actual supply function to be estimated depends on the particular purpose of the analysis, the available data, and the available econometric software. In the case of the simple stay-leave decision, either logit or probit [17, 24] analyses could be used. If only aggregate data are available, one can form a log odds ratio from the retention rate and estimate weighted OLS.

Modeling the reenlist-extend-leave decision is more complicated because the pay variable is conditioned on the choice made. However, a combination of conditional and multinomial logit techniques can be used (see [13, 14]).

1. Such a model is described in [8] and simulated in [23].
2. See [23] for a more detailed exposition of these points. This is not a settled question in the current literature. It is understood that [9] will compare these competing specifications. Possibly further insights will be presented there.

Enlistment Supply Analysis

Work on enlistment supply has had two periods over the past 15 years in which it has contributed greatly to the debate on military manpower issues. The first was around 1970, when a significant body of work (such as [25, 26, 27]) was produced for the President's Commission on an All-Volunteer Armed Force (The Gates Commission). This work supplied evidence that enlistments would respond to pecuniary incentives to the extent that the budgetary cost of an all-volunteer force would not be excessive, particularly compared to estimates of the social cost of the draft.

The second period of high visibility came in the late 1970s when the services were not meeting their enlistment quotas. This work (such as [11, 20, 28]) used better econometric techniques, richer data, and more sophisticated models. It demonstrated that the primary reason for this shortfall in accessions was the decrease in relative military pay for enlistees and revalidated the conclusion that required accessions could be obtained if pay levels remained competitive with civilian pay.

It has been asserted (see quotations in [29], for example) that enlistment supply will once again become an important issue in the late 1980s and early 1990s when smaller youth cohorts enter the 17-to-21-year-old age group. Preliminary estimates indicate that military pay for new enlistees will have to rise between 5 percent [29] and 10 percent [30] relative to civilian wages for those groups to obtain accession cohorts comparable to those of the past decade. However, due to the experience profile of the AVF, cohorts of this size may not be necessary [29, pp. 21-23]; and due to the relative costs of enlisting new enlisted personnel versus retaining current personnel, such large accession cohorts may not be desirable [4, 5, 12, 15].

The modeling of enlistment is a relatively straightforward rearrangement of a reservation wage model. Construction of the decision point is similar to the retention analysis discussed earlier in the form $M - C \rangle T_c - T_m$, where M is military compensation, C is civilian compensation, and T_i is monetized tastes for civilian and military life. This condition says that, all other things being equal, individuals will enlist if the net military wage is larger than the net monetized value of civilian life.

Enlistment supply estimation is usually done at a more aggregate level than analysis of the reenlistment decision. The number of contracts for high-quality enlistees divided by the youth population in a geographic area is

explained by pecuniary and demographic factors, and by the recruiting resources expended. Due to more complete data and a wider diffusion of knowledge of advanced econometric techniques, more recent studies ([31, 32]) have used variance components estimation procedures, or at least have tested for stability of the regression coefficients over time [11].

Many interesting measurement issues have been raised during this work on enlistment supply. Several are discussed below.

1. Supply-Limited Versus Demand-Limited Recruitment. Historically the Navy has had difficulty filling its perceived demand for high-quality enlisted personnel (usually defined as high school graduates in the upper half of the mental group distribution). That is, Navy recruitment is limited by the supply of enlistees. Therefore, changes in the enlistment behavior of these groups can be expressed as movements along or shifts in a supply curve. Since there is a perceived shortage of these individuals, the Navy is interested in understanding how it can attract more volunteers. But for all other groups, the Navy is able to obtain more potential enlistees than it wants. Therefore, the Navy's demand for these individuals is the limiting factor. Estimating supply curves for these groups might be econometrically challenging, but the lack of policy implications in the results means this project has not been pursued.

2. Accessions Versus Contracts. Most recent work has focused on explaining the number of people who sign enlistment contracts, rather than the number of people who actually leave for recruit training in a given month or year. The reason is that between the time most people sign a contract and the time they actually leave, they spend varying amounts of time in the Delayed Entry Program (DEP). When recruiting is good, recruiters store up individuals in the DEP, and when times are bad they draw from this pool. This is particularly true for high-quality personnel.

3. Relative Pay. Those studies that use military pay tend to use the current pay of a recent recruit, with no effort to formulate a present value. Given the high discount rates of 17- and 18-year-olds (see [11, 33]), this approach is reasonable. Civilian pay is often proxied with the pay of all production workers rather than the more intuitively appealing measure, youth compensation. At least one study [11] has offered evidence that the average full-time equivalent earnings of 17- to 21-year-olds is a much better proxy for civilian pay. However, it is an extremely complicated and expensive undertaking to obtain this variable.

4. Unemployment – Youth Versus All. Reasoning by analogy from the previous paragraph, it would seem that a youth unemployment rate would be preferable to an overall unemployment rate as a variable. However, sufficiently disaggregate youth unemployment data do not exist, and arguments have been advanced [33] that trying to develop such data will not be worthwhile without, at a minimum, a sophisticated modeling of the participation of youths in the labor force and its effect on this unemployment rate.

5. Other-Service Recruiters. An important question for the Department of Defense and the services individually is whether other-service recruiters complement one another or compete against one another. Those few studies that do estimate these effects (such as [11]) find complementarity, but multicollinearity among services' recruiters is so strong that the results should be taken as tentative. (For example, [11] reports that, on the margin, additional Air Force recruiters have a stronger positive effect on Navy contracts than do additional Navy recruiters. This is not an intuitively appealing result.)

A representative model (from [11]) with regression results is shown below. It uses annual data for FY 1976T-80 covering 43 Navy Recruiting Districts. The dependent variable is the log of the ratio of contracts signed by upper-mental-group, non-prior-service high school diploma graduates to total district population.

NAVY SUPPLY MODEL

Explanatory variables	Coefficient
Constant	-0.57 (1.47)
Relative pay Pay for E-1 divided by full-time equivalent pay for 18-year-old male	0.93 (6.55)
Unemployment Civilian unemployment rate	0.29 (4.85)
Employment and Training Administration (ETA) youth programs	0.039 (0.49)
ETA countercyclical programs (CETA)	-0.086 (2.12)
Navy production recruiters (those with recruiting quotas)	0.74 (9.72)
Total recruiting district population	0.12 (2.29)
Percent of district population who are black	-0.0062 (4.04)
Dummy for absence of G.I. Bill (i.e., presence of VEAP)	-0.15 (3.70)
R^2	0.63
Standard error of the regression	0.19
Population elasticity (calculated)	0.42 (4.34)

Notes: ETA programs and recruiters are divided by district population.

All variables except percent black and the dummy for G.I. Bill are in natural logs.

All coefficients except percent black, G.I. Bill, and population are directly interpretable as partial elasticities.

t-statistics are in parentheses.

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