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Nuclear Officer Retention:

MSR and Beyond

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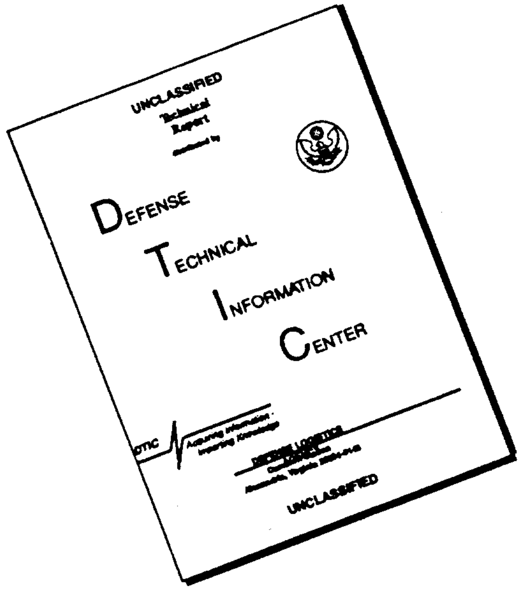

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13. ABSTRACT *(Maximum 200 words)*

To combat low retention in the nuclear officer community, the Nuclear Officer Incentive Pay (NOIP) program was designed. A 1981 study of nuclear submarine officer retention found a significant, positive effect of NOIP on their retention at the end of the minimum service requirement (MSR). In 1996, the study was broadened to include nuclear-trained surface warfare officers. Again, a significant, positive effect of NOIP on the MSR retention rate was found.

This report documents the results of an investigation of historical nuclear officer retention behavior at the MSR decision point and 9 decision points later. It specifies an ACOL-2 model and quantifies the impact of the NOIP retention bonus program on 10 retention decisions.

Separate models of retention were estimated for the submarine and surface nuclear officer communities. For both communities, the retention elasticities with respect to the NOIP retention bonus program were small, but significant indicating that "pay does matter."

These models can be used to assess the retention and cost impacts of alternative NOIP retention strategies.

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Foreword

This report was prepared as part of the New Modeling Systems to Forecast the Effects of Compensation on Officer and Enlisted Retention Behavior project (Program Element 0603707N), under the sponsorship of the Chief of Naval Personnel (PERS-2). The objective of this project is to quantify the effect of the Nuclear Officer Incentive Pay program on nuclear officer retention at 10 decision points. The work described here was performed in FY95 and FY96.

This research benefited greatly from contributions by several individuals. Kimberly Darling of SAG Corporation provided research support for the entire project; Kenneth O'Brien of SAG wrote the program that constructed the estimation data set and calculated the Annualized Cost of Leaving (ACOL) variable. Steve Cylke of PERS-222F and Paul Hogan of the Lewin Group offered valuable comments on potential modeling approaches and interpretation of the final results. CDR Steve Struble and LCDR Mike Dobbs of PERS-211N shared their institutional knowledge of the Nuclear Officer community, as well as valuable data on the Nuclear Officer Incentive Program.

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Summary

Background

The Nuclear Officer Incentive Pay (NOIP) program was designed to combat low retention in the nuclear officer community, but its legislative authorization expired in FY96. To justify new authority for NOIP, current estimates of its effects on retention were required.

Previous to the current analyses on the effects of the NOIP program on nuclear officer retention, only a single study of nuclear submarine officers in 1981 was conducted. In that study, the effects of NOIP on retention at the end of the minimum service requirement (MSR) were quantified. In 1996, the effects of NOIP on retention at the end of the MSR were quantified again; the results are found in NPRDC TN-96-25. Because NOIP's retention bonuses impact retention decisions out to the 26th year of commissioned service, the impact of NOIP on retention decisions after the MSR decision point needed quantification.

Under the current NOIP program, a nuclear officer who decides to remain in the Navy can opt for the Continuation Pay (COPAY), or the Annual Incentive Bonus (AIB). With COPAY, an officer can choose a 3-, 4-, or 5-year contract. AIB, on the other hand, requires no contractual obligation. With a MSR of 5 years, then, an officer with 10 years of service could have made only one stay decision (i.e., at MSR, choose a 5-year COPAY), or five stay decisions (e.g., at MSR and each year thereafter, choose AIB). In a cross-section of officers, one will find that they have made a different number of stay decisions at a particular year of service.

Objective

The objective of this report is to quantify the effect of the NOIP program on nuclear officer retention at the MSR and subsequent decision points.

Approach

The approach includes: (1) developing a model of retention behavior, (2) estimating the model, and (3) simulating the effect on retention of alternative NOIP retention bonus strategies.

Results

Separate models of retention were estimated for the submarine and surface nuclear officer communities. For both communities, the retention elasticities with respect to the changes in pay were small. For submarine officers, the retention-pay elasticity at the first decision point was 0.49. That is, for a 10 percent increase (decrease) in regular military compensation (RMC), a 4.9 percent increase (decrease) in the first decision point retention rate was estimated. By the 5th decision point, the elasticity had declined to 0.12. From the 6th through 10th decision points, the elasticity ranged between 0.09 and 0.04.

For surface nuclear officers, the retention-pay elasticity at the first decision point was 0.61. That is, for a 10 percent increase (decrease) in RMC, a 6.1 percent increase (decrease) in the first

decision point retention rate was estimated. By the 5th decision point, the elasticity had declined to 0.14. From the 6th through 8th decision points, the elasticity ranged between 0.06 and 0.11.

Because NOIP comprises a smaller percentage of total military pay than does RMC, retention elasticities based on increases in NOIP retention bonuses are markedly lower. For submarine officers, the retention-bonus elasticity at the first decision point is 0.09; it falls to 0.02 by the 5th decision point. For surface nuclear officers, the first-decision retention-bonus elasticity is 0.12, falling to 0.02 at the 5th decision point.

Conclusions

The retention-pay elasticities found in these models are relatively small, but their statistical significance points to the fact that pay matters. These models can be used to assess the retention and cost impacts of alternative NOIP retention strategies.

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Introduction

The Nuclear Officer Incentive Pay (NOIP) program was initiated in June 1969 to combat the shortage of nuclear-trained submarine officers. In October 1972, nuclear-trained surface warfare officers were included in the program. The program expired in June 1975. It was not restarted until August 1976 when the current structure of NOIP with Continuation Pay (COPAY), Annual Incentive Bonus (AIB), and an accession bonus was implemented. Over the years, authorization for the NOIP program has been expanded; COPAY for 3-, 4-, and 5-year contracts out to the 26th year of commissioned service were authorized. Annual payment amounts have also increased. The current authorization, which was enacted in 1987 and expired in 1996, provided for up to $12,000 per year for COPAY, $7,200 per year for AIB, and $6,000 for the accession bonus.

For the FY81 NOIP legislative authority, Nakada (1981) conducted a study of nuclear submarine officer retention. In that study, both COPAY and AIB had positive effects on retention at the end of the minimum service requirement (MSR). In 1996, Nakada (1996) again found that both COPAY and AIB had positive effects on the MSR retention of nuclear submarine officers. The 1996 study was expanded to include nuclear-trained surface warfare officers, who also experienced positive effects of COPAY and AIB on MSR retention. NOIP's retention bonuses impact retention decisions out to the 26th year of commissioned service. The availability of historical nuclear officer retention data allowed for the assessment of NOIP on retention decisions after the MSR decision point.

Approach

The approach includes: (1) developing a model of retention behavior, (2) estimating the model, and (3) simulating the effect on retention of alternative NOIP retention bonus strategies.

Economic Model of Nuclear Officer Retention

While there is a relatively rich economic literature on enlisted retention behavior, there has been relatively less research conducted on officer retention. In addition to Nakada's 1981 nuclear submarine officer study, Kleinman and Zuhoski (1980) estimated the effect of the Aviation Career Incentive Pay (ACIP) program on Navy pilot retention.

Gotz and McCall (1983) estimated a dynamic retention model for Air Force captains. The Gotz-McCall theoretic framework explicitly controls for self-selection that occurs as retention rates rise with tenure. However, policy simulations are difficult to generate using the dynamic retention framework, and estimated parameters from this study were not published. (It was later "calibrated" for Air Force enlisted personnel by Arguden (1986). Hogan and Goon (1989) estimated a simple Annualized Cost of Leaving (ACOL) model for Air Force officers by occupational specialty. They included other variables to control for censoring in the error structure inherent in ACOL and arrived at pay elasticities in the .3 to 1.1 range.

More recently, Mackin, Hogan, and Mairs (1993) have estimated an ACOL-2 model for Army officers. This 1993 study develops a multi-period model for Infantry and Signal Corps officers.

Mackin, Hogan, and Mairs (1994) also used the ACOL-2 model to estimate parameters for the Officer Personnel Inventory, Cost and Compensation (OPICC) model for Army officers. In this application, estimated pay elasticities fell into a similar but wider range compared with estimates from Mackin, et. al. (1993). This wider range can, in part, be explained by the fact that different groups were studied in 1993 and 1994. The 1993 study was limited to Infantry and Signal Corps officers, while the 1994 sample consisted of all officer-types included in the Army Research Institute's (ARI) Officer Longitudinal Research Data Base. However, the main reason for variation in the pay elasticity estimates comes from the year of service (YOS) range under investigation. The wider range of pay elasticities calculated in Mackin, et. al. (1994) corresponds directly to the wider YOS range.[1]

Table 1 summarizes the pay elasticity estimates for officers in these studies.

Table 1

Estimated Officer Retention Pay Elasticities (Previous Studies)

Officer Studies	Service	YOS	Years Studied	Pay Elasticities
Kleinman & Zuhoski (1980)	Navy Pilots	MSR to MSR +4	FY 63-78	0.3-3.3
Nakada (1981) and (1996)	Navy nuclear officers	MSR MSR	FY 72-78 FY 79-94	1.4 .15-.35
Gotz & McCall (1983)	Air Force	7-30	FY 70	Not Reported
Hogan & Goon (1989)	Air Force	5-12	FY 76-88	0.3-1.1
Mackin, Hogan, & Mairs (1993)	Army	3-11	FY 79-90	0.040-0.396
Mackin, Hogan, & Mairs (1994)	Army	1-15	FY 79-92	0.029-0.599

Economic models of occupational choice applied to military retention decisions assume that individuals rank jobs based on the pecuniary and non-pecuniary attributes of those jobs, and choose a job, or time path of jobs, that provides the greatest satisfaction or utility over the individual's lifetime.[2] Pecuniary attributes consist of military pay and civilian earnings opportunities. Non-pecuniary attributes include preference for military service, hardship associated with a duty station, and family separation, for example.

The utility function describes the individual's preferences (or values) for current and expected future military and civilian pay, and military service (e.g., rotation frequency, hours of work). The value of the i^{th} attribute of a Navy job is represented by X_{iN} and the value of the i^{th} attribute of the

[1]In the 1994 study, the lowest pay elasticity, 0.029, is for YOS 15 and the highest, .599, is for YOS 1. The 1993 study only includes YOS 3-11.

[2]See, for example, Smith, et. al. (1991); Black and Hogan (1987); Hogan and Goon (1989); and, for a review of methods and research issues, Hogan and Black (1991).

best civilian career opportunity is represented by $X_{i,C}$. According to this model, an individual stays in the Navy if:

$$U(X_{i,N},...,X_{n,N}) > U(X_{i,x},...,X_{n,C}). \tag{1}$$

The function *U*(...) is not, of course, known to the researcher, nor are all the factors that affect a member's decision known and measurable by the researcher. One popular empirical formulation that makes assumptions concerning this "ignorance" and incorporates it into the model is the "random utility" model. It assumes an explicit functional form of the utility function having an unobservable random component. For example, a linear utility function results in the following model.

Individual *j* will stay if and only if:

$$X_{j,N}\beta + \gamma_{j,N} > X_{j,C}\beta + \gamma_{j,C} \tag{2}$$

or

$$(X_{j,N} - X_{j,C})\beta > \gamma_{j,C} - \gamma_{j,N} \tag{3}$$

where $X_{j,N}$ is a vector of attributes associated with a Navy job, $X_{j,C}$ is a vector of attributes associated with the best civilian alternative, β is a vector of coefficients to be estimated and the γs represent unobservable (to the researcher) aspects of the utility or satisfaction associated with Navy and civilian alternatives. The difference $\gamma_{j,C} - \gamma_{j,N}$ is represented by the variable γ_j, which is distributed over the population of potential stayers according to $f(\gamma)$.[3] Then, the probability that individual *j* stays is:

$$Prob[(X_{j,N} - X_{j,C})\beta > \gamma_j] = \int_{-\infty}^{(X_{j,N} - X_{j,C})\beta} f(\gamma)d\gamma. \tag{4}$$

If γ is distributed $N(0,\sigma_\gamma)$, then

$$Prob[(X_{j,N} - X_{j,C})\beta > \gamma_j] = \int_{-\infty}^{(X_{j,N} - X_{j,C})\beta/\sigma} f(\gamma')d\gamma'. \tag{5}$$

where γ' is a standard normal random variable. This model can be estimated as a probit.

The Annualized Cost of Leaving Model (ACOL) is derived from this random utility framework simply by specifying that the individual considers the entire future time path of military and civilian income in a rational way. In particular, the differences in the *X*s representing military and civilian pay are replaced by the annualized or annuitized difference of the present value of these variables calculated over a horizon which maximizes the annualized difference. The decision rule becomes: stay at time *t* if and only if

---

[3]Note that individual attributes, assumed to be correlated with an individual's taste for various job attriubtes, can be included in the model, presumably reducing the dispersion of the unobserved component.

$$ACOL_{j,t} + Z_{j,t}\beta > \gamma_{j,t} \ , \qquad (6)$$

where $Z_{j,t}$ represents the net difference between other Navy and civilian alternative attributes (X_N - X_C).

The empirical definition of the simple ACOL model derived above does not account for unobserved heterogeneity. (Heterogeneity is an explanation for observationally identical officers who display different retention propensities that remain fixed because of permanent differences in tastes for military service and other unobserved factors such as marketable skills.) Because retention rates rise with tenure, the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. The simple ACOL model does not capture this change. Consequently, if measured factors are correlated with this changing distribution of unobserved factors, the coefficients in the ACOL model are potentially biased.

The ACOL-2 (panel probit) formulation follows directly from this framework when one explicitly provides greater structure to the unobserved component of the decision rule, $\gamma_{j,t}$. In particular, let this error term consist of two parts. The first is an individual-specific, permanent component, α_j, while the second is a transitory component, $\varepsilon_{j,t}$:

$$\gamma_{j,t} = \alpha_j + \varepsilon_{j,t} \ . \qquad (7)$$

The decision rule, ignoring Z, becomes stay if and only if:

$$ACOL_{j,t} - \alpha_j > \varepsilon_{j,t} \ . \qquad (8)$$

Now, include the Z attributes affecting the decision to stay, such that:

$$X_{j,t}\delta = (ACOL_{j,t}, Z_{j,t})(1, \beta) \ . \qquad (9)$$

Following the decision rule, the probability that an individual will stay is:

$$Prob[X_{j,t}\delta - \alpha_j > \varepsilon_{j,t}] = \int_{-\infty}^{(X_{j,t}\delta - \alpha_j)} f(\varepsilon_{j,t})d\varepsilon_{j,t} \ . \qquad (10)$$

With ε distributed normally with mean zero and standard deviation σ_ε, the probability that the individual stays in period t, given that the individual has stayed through period t - 1, is given by

$$\int_{-\infty}^{(X_{j,t}\delta - \alpha_j)} f(\varepsilon_{j,t})d\varepsilon_{j,t} = F\left[\frac{X_{j,t}\delta - \alpha_j}{\sigma_\varepsilon}\right] \ , \qquad (11)$$

where $F(...)$ is the cumulative distribution function of the standard normal random variable.[4] Then, the probability that an individual enters at $t = 1$, stays through $T - 1$ periods, and leaves in period T, is given by:

$$Q_T = \prod_{t=1}^{T-1}\left(F\left[\frac{X_{j,t}\delta - \alpha_j}{\sigma_\varepsilon}\right]\right) . \mathrm{F}\left[\frac{-(X_{j,T}\delta - \alpha_j)}{\sigma_\varepsilon}\right] . \qquad (12)$$

This is a one-factor, variance-components formulation, which has the following interpretation. When an officer arrives at a decision point, it is as if he/she draws an $\varepsilon_{j,t}$ at random from a distribution $f(\varepsilon_{j,t})$ with mean zero. This distribution is the same for all officers. Moreover, if the officer stays and comes to another decision point, he/she again draws randomly from the same distribution. This value will be uncorrelated with the previous draw. In addition, the officer has a "permanent" component, α_j, that remains constant across decision points. This component is distributed over all officers according to the density function $f'(\alpha)$, which is also assumed to be normal. An officer cohort's distribution of α's changes as officers pass through multiple decision points. Those with relatively greater preferences for Navy service (higher α's) will tend to stay at higher rates, so that the distribution of α's for the remaining officers is censored.

For a cohort of officers who enter at period 1, the proportion who stay through period T-1, and then leave at T, is:

$$Q_T = \int_{-\infty}^{\infty}\prod_{t=1}^{T-1}\left(F\left[\frac{X_{j,t}\delta - \alpha_j}{\sigma_\varepsilon}\right]\right) . \mathrm{F}\left[\frac{-(X_{j,T}\delta - \alpha_j)}{\sigma_\varepsilon}\right] f'(\alpha_j) d\alpha_j . \qquad (13)$$

where $f'(\alpha)$ is the density function of α, with mean u_α. Now, if α and ε are independent, then

$$\sigma^2_\gamma = \sigma^2_\varepsilon + \sigma^2_\alpha . \qquad (14)$$

Define the parameter:

$$\rho = \frac{\sigma^2_\alpha}{\sigma^2_\alpha + \sigma^2_\varepsilon} = \frac{\sigma^2_\alpha}{\sigma^2_\gamma} . \qquad (15)$$

This parameter represents the correlation in the total disturbance term between successive time periods. Assuming that the transitory component of the error term, ε, is uncorrelated over time, this term represents the importance of the fixed component of "tastes," α, in explaining the pattern of retention rates over time. Also, define $g_j = (\alpha_j - u_\alpha)/\sigma_\alpha$, implying that $\alpha_j = u_\alpha + \sigma_\alpha g_j$.

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[4]Note that 1-F[-C] = F [C], by the symmetry of the standard normal distribution.

Next, note that[5]

$$\sigma_\varepsilon = \sigma_\gamma(1-\rho)^{1/2}\ ;\ \frac{\sigma_\alpha}{\sigma_\varepsilon} = \left[\frac{\rho}{(1-\rho)}\right]^{1/2}. \tag{16}$$

Let the expression for the ratio of the standard deviation in the permanent component of the error to the standard deviation in the transitory component be denoted by r. Further, let $y_{j,t} = 1$ for those who stay in period t, and $y_{j,t} = 0$ for those who leave in period t. The expression for the cohort survival rate to time T can now be rewritten as

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{X_{j,t}\delta - u_\alpha}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2y_{j,t}-1)f'(\alpha_j)d\alpha_j\ . \tag{17}$$

Making additional substitutions for $f'(\alpha)$,

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{X_{j,t}\delta - u_\alpha}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2\,y_{j,t}-1)\frac{1}{(2\pi)^{1/2}}\exp^{-g_j^2/2} dg_j\ . \tag{18}$$

The variable ρ measures the proportion of the variance in the error that is accounted for by individual-specific factors affecting retention rates (α). If it is positive, retention rates will tend to rise simply as a result of the sorting process, with those having a low "taste" for military life selecting themselves out at early decision points. The coefficient on the ACOL variable is equal to $(1/\sigma_\gamma(1-\rho)^{1/2})$. Hence, officers will be more responsive to pay differences if (a) the dispersion or variance in unmeasured factors, σ_γ, is lower and (b) the systematic component of unobserved factors affecting officer retention is greater (i.e., ρ is greater).

This model of voluntary stay-leave decisions includes multiple decision points for all officers. A decision point, for which a retention rate is estimated, is a year-long interval over which the officer is assumed to be free to leave the Navy, should he choose to do so. The first decision point is the year in which the officer's initial service obligation ends. This may be as early as the 4th year

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[5]To see this result, recall that

$$\rho = \frac{\sigma^2_\alpha}{(\sigma^2_\alpha + \sigma^2_\varepsilon)}\ .$$

Solving this equation obtains the expression for $\sigma_\alpha/\sigma_\varepsilon$. Also, note that the expression can be rewritten as:

$$\rho = \frac{\sigma^2_\gamma - \sigma^2_\varepsilon}{\sigma^2_y}\ .$$

Solving this expression for σ_ε obtains the expression in the text.

of service for some officers, although most nuclear officers will first make a decision in the 6th year of commissioned service (YCS). All officers in the sample are not observed through the same number of decision points, of course. Some leave before reaching the maximum YCS, and, in some instances, the period for which there is data ends prior to reaching this point. Further, since officers in the panel may be under additional obligations (e.g., for a promotion) for a portion of the panel range, they may be unobserved at intermediate decision points.

Estimation of panel probit models with multiple decision points has been computationally impractical because of the necessity of evaluating multiple integrals. The formulation presented above reduces the problem to the evaluation of a single integral. However, it includes the product of several univariate normal probabilities. Butler and Moffitt (1982) have applied a numerical integration procedure based on Gaussian quadrature, which reduces the computational burden.

Consider again the following equation:

$$Q_T = \int_{-\infty}^{\infty} \prod_{t=1}^{T} F\left[\frac{X_{j,t}\delta - u_\alpha}{\sigma y 1 - \rho)^{1/2}} - rg_j\right](2y_{j,t} - 1)\frac{1}{(2\pi)^{1/2}}\exp^{-g_j^2/2}\, \mathrm{d}g_j . \tag{19}$$

Define $q^2 = g_j^2/2$, implying that $g_j = q(2)^{1/2}$. Then the expression for Q_T can be written as:

$$Q_T = \int_{-\infty}^{\infty} K_{jT}(q)e^{-q^2}dq , \tag{20}$$

where

$$K_{jT} = \prod_{t=1}^{T} F\left[\frac{X_{j,t}\delta - u_\alpha}{\sigma_\gamma(1-\rho)^{1/2}} - rg_j\right](2y_{j,t} - 1)\frac{1}{\pi^{1/2}} . \tag{21}$$

This integral can be approximated by

$$Q_T = \sum_{h=1}^{H} k_h K_{jT}(q_h) . \tag{22}$$

where H is the number of evaluation points, and k_h are the Hermite weights for approximating the integral at the evaluation points.[6] The expression in Equation 22 is the contribution to the likelihood function for one individual observed across T decision points. Assume that the model is estimated for a sample of N officers. The log-likelihood function is expressed as:

[6]Hermite integration is a form of numerical integration (or quadrature) that uses weighting coefficients and unequally spaced evaluation points. Allowing the evaluation points, or abscissas, to vary increases degrees of freedom, allowing one to approximate the integral fairly accurately with fewer evaluation points than in a traditional quadrature technique. For a further discussion, see Butler and Moffitt (1982).

$$\ln(L) = \sum_{n=1}^{N} \ln(Q_T) . \tag{23}$$

Model Estimation and Results

Data

The primary data source for this research was the Navy's Officer Master File. Cohorts of nuclear-trained officers were assembled and tracked. Cohorts were categorized by fiscal year in which officers were commissioned. Complete officer data prior to FY74 was not available. Thus, the first cohort in the data set was the FY74 cohort.

The data set contained 10,357 officers. Only unrestricted line officers were considered; limited duty and warrant officers (149 observations) were dropped from the data set. Censored observations totaling 2,121 officers were also deleted. Officers were censored if: (1) they had not completed their minimum service requirement (MSR) (1,817 observations), or (2) they attrited prior to MSR (304 observations).

From the remaining 8,087 observations, 45 additional officers, who had missing data, were excluded from the final data set. The data set that was used to estimate the models, then, contained 8,042 observations.

Over the period which this data set covers, officers' decisions regarding length of obligation has changed. Until the passage of the DoD Authorization Act, 1986, officers could only choose a COPAY obligation of 4 years. From FY 1987 on, however, 3-, 4-, and 5-year obligations can be observed. Figure 1 shows the percentage of officers under each COPAY obligation by YCS for FY 1987 through FY 1994 combined. Officers overwhelmingly choose the 3-year obligation relative to the longer obligations, although the proportion who choose the 5-year option climbs after YCS 8. For example, of those officers who chose to stay with a COPAY obligation at YCS 6, less than 50 percent of them chose the 4- or 5-year obligation while more than 50 percent of them chose the 3-year contract.

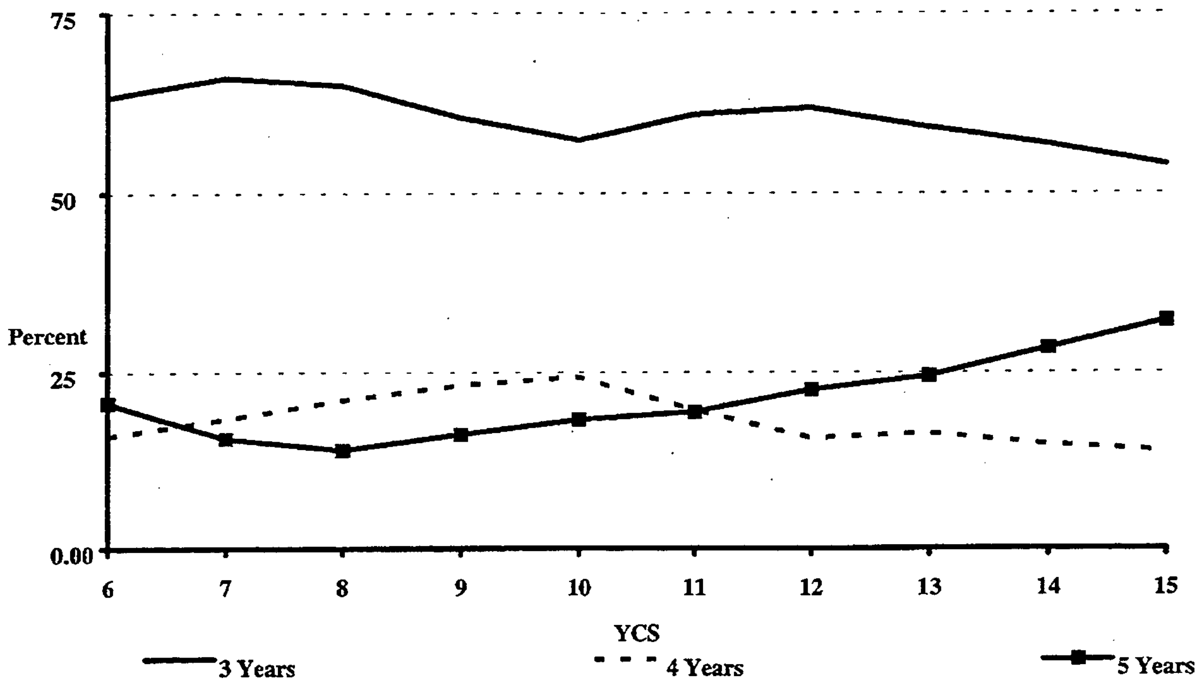

Figure 1. Percent under 3-, 4-, and 5-7 year COPAY obligation by YCS (FY87-FY94)

Table 2 shows that the fraction of officers under 3- and 5-year obligations has risen since FY 1987. About 16 percent of officers were under a 5-year COPAY obligation in FY87, compared to nearly 34 percent in FY94. Similarly, the proportion under a 3-year obligation rose from 43 percent in FY87 to peak at 72 percent in FY90. Part of the increase may be attributed to a "phasing in" of the 3- and 5-year obligations. That is, officers who were already serving 4-year obligations would not choose a different obligation until their current obligations expired.

Table 2

Fraction Under 3- and 5-year Obligation by YCS and FY

	Fraction Under 3-year Obligation								
	Fiscal Year								
YCS	**87**	**88**	**89**	**90**	**91**	**92**	**93**	**94**	**All FYs**
6	0.5079	0.6438	0.7597	0.8000	0.8269	0.6071	0.4458	0.3971	0.6333
7	0.3689	0.5680	0.6573	0.7225	0.8191	0.7984	0.6460	0.5673	0.6601
8	0.4894	0.4530	0.6883	0.6466	0.6272	0.7704	0.7769	0.6296	0.6494
9	0.4662	0.6283	0.7388	0.6839	0.5683	0.5824	0.6211	0.5862	0.6054
10	0.4160	0.6012	0.7442	0.7746	0.6812	0.4208	0.5338	0.4480	0.5742
11	0.4314	0.6667	0.7290	0.7143	0.7559	0.5088	0.5000	0.5368	0.6093
12	0.3488	0.6698	0.8667	0.7183	0.7009	0.5106	0.4948	0.5426	0.6182
13	0.3684	0.4783	0.7304	0.8229	0.6815	0.5111	0.5067	0.4028	0.5915
14	0.4500	0.4833	0.6204	0.7383	0.7379	0.4455	0.4444	0.4769	0.5683
15	---------	0.5294	0.6232	0.6182	0.7115	0.5517	0.3398	0.3538	0.5396
	Fraction Under 5-year Obligation								
6	0.1111	0.1918	0.0842	0.1182	0.1154	0.2321	0.4458	0.3971	0.2067
7	0.2039	0.1280	0.1033	0.0983	0.0955	0.1550	0.6460	0.5673	0.1562
8	0.0851	0.2137	0.0779	0.1164	0.1479	0.1071	0.7769	0.6296	0.1402
9	0.1169	0.1770	0.1119	0.0774	0.1498	0.1706	0.6211	0.5862	0.1626
10	0.1040	0.1595	0.1163	0.1127	0.0870	0.2295	0.5338	0.4480	0.1830
11	0.1275	0.1429	0.1226	0.1429	0.1575	0.1491	0.5000	0.5368	0.1938
12	0.3140	0.1415	0.0571	0.1408	0.2056	0.3191	0.4948	0.5426	0.2249
13	0.2632	0.3261	0.0696	0.0938	0.1926	0.3667	0.5067	0.4028	0.2445
14	0.2667	0.2833	0.2222	0.0935	0.1845	0.4000	0.4444	0.4769	0.2835
15	---------	0.2794	0.2029	0.2455	0.1442	0.2989	0.3398	0.3538	0.3218

Table 3 shows the number of observations in the sample by decision point.[7] None of the model specifications used more than ten decision points because of the small number of observations. The

[7]Note that the number of observations in the sub and surface communities does not equal the total after the first decision. For the sub officers, we censored decision points if they switched to surface.

Surface sample did not include any "leavers" after the eighth decision point. Note that references to the surface community, surface warfare community, surface officers, or SWOs in this report refers to the nuclear-trained surface warfare officer community.

Table 3

Number of Observations by Decision Point and Sample

Decision Point	Full Sample	Submarine Community	Surface Community
1	8,042	6,424	1,618
2	4,823	3,900	899
3	3,473	2,858	599
4	2,335	1,910	415
5	1,499	1,214	276
6	951	760	185
7	616	484	127
8	366	273	89
9	198	134	----
10	111	69	----

Several different model specifications were estimated. The model specifications differed in the inclusion/exclusion of the following independent variables. Note that STAY is the dependent variable in all the specifications.

- *STAY*—dependent variable equal to 1 if the officer stayed, 0 if the officer left.
- *ACOL*—Annualized Cost of Leaving (as defined in Appendix B).
- *Unemployment rate*—national average unemployment rate.
- Nonwhite—dichomotomous variable equal to 1 if nonwhite, 0 if white.
- *Academy*—dichomotomous variable equal to 1 if Academy is source of commission.
- *NROTC*—dichomotomous variable equal to 1 if NROTC is source of commission.
- *Dependents status*—dichomotomous variable equal to 1 if officer has any dependents, 0 otherwise.
- *Years since last decisio*n—deviation from mean number of years between decisions at each decision point. In these specifications, this variable does not affect the first decision.
- *MSR 3*—dichomotomous variable equal to 1 if the officer's MSR is 3 years. Applies only to first decision.
- *MSR 4*—dichomotomous variable equal to 1 if the officer's MSR is 4 years. Applies only to first decision.
- *Median duration of unemployment*—alternative measure of civilian opportunities using typical unemployment duration (annual averages) for workers in managerial and profes-

Table 4 provides the mean values of the dependent variable and the explanatory variables by decision point and sample.

Table 4

Mean Values of Key Variables by Decision Point and Sample

	Full Sample									
	Decision Point									
Variable	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
STAY	0.716	0.877	0.806	0.835	0.848	0.903	0.929	0.948	0.980	0.973
ACOL	25,635	27,466	29,836	32,412	35,112	38,580	41,807	45,239	46,821	50,525
Unemp. Rate	6.798	6.816	6.809	6.744	6.595	6.415	6.332	6.364	6.282	6.189
Nonwhite	0.030	0.029	0.026	0.024	0.016	0.019	0.023	0.014	0.010	0.009
ACAD	0.373	0.396	0.433	0.444	0.450	0.449	0.455	0.467	0.470	0.441
NROTC	0.275	0.274	0.282	0.271	0.258	0.268	0.268	0.287	0.273	0.243
Dep. Status	0.478	0.572	0.661	0.716	0.763	0.795	0.808	0.811	0.813	0.847
Yrs Since Last Decision	-------	1.293	1.497	1.296	1.307	1.358	1.268	1.265	1.147	1.207
MSR 3	0.061	-------	-------	-------	-------	-------	-------	-------	-------	-------
MSR 4	0.206	-------	-------	-------	-------	-------	-------	-------	-------	-------
Med Dur. Unemp.	8.764	8.784	9.097	9.323	9.343	9.103	9.010	9.272	9.213	9.134
	Submarine Warfare Sample									
STAY	0.732	0.886	0.800	0.834	0.842	0.909	0.928	0.930	0.970	0.986
ACOL	26,763	28,605	30,909	33,476	36,460	41,110	43,434	47,011	48,608	52,138
Unemp. Rate	6.798	6.800	6.779	6.731	6.587	6.404	6.339	6.363	6.297	6.245
Nonwhite	0.029	0.030	0.028	0.024	0.017	0.020	0.025	0.015	0.008	0.000
ACAD	0.363	0.386	0.426	0.433	0.444	0.447	0.463	0.465	0.485	0.449
NROTC	0.270	0.272	0.280	0.268	0.255	0.257	0.246	0.267	0.246	0.217
Dep. Status	0.489	0.580	0.667	0.715	0.768	0.792	0.804	0.799	0.969	0.812
	Surface Warfare Sample									
STAY	0.653	0.845	0.843	0.843	0.870	0.876	0.945	0.978		
ACOL	21,151	22,709	24,924	27,655	29,430	32,517	35,925	39,770		
Unemp. Rate	6.797	6.878	6.936	6.801	6.620	6.477	6.310	6.347		
Nonwhite	0.036	0.026	0.018	0.022	0.014	0.016	0.016	0.011		
ACAD	0.412	0.443	0.469	0.492	0.482	0.459	0.441	0.472		
NROTC	0.295	0.284	0.295	0.284	0.264	0.308	0.331	0.337		
Dep. Status	0.435	0.545	0.633	0.728	0.739	0.805	0.827	0.854		

Results

Eight separate specifications of the retention equation were estimated. The alternative specifications vary according to the sample (Full, Sub, and Surface) and the explanatory variables included (see Table 5). This paper reports estimates from the following specifications:[8]

Table 5

Model Specifications

No.	Description	Sample	Explanatory Variables
1	Basic Model	Full	• ACOL • Unemployment Rate
2	Submarine Basic Model	Submarine Only	• ACOL • Unemployment Rate
3	Surface Warfare Basic Model	Nuclear-Trained Surface Warfare Only	• ACOL • Unemployment Rate
4	Demographics	Full	• ACOL • Unemployment Rate • Nonwhite • Academy • NROTC • Dependents Status
5	Submarine Demographic Model	Submarine Only	• ACOL • Unemployment Rate • Nonwhite • Academy • NROTC • Dependents Status
6	Surface Warfare Demographic Model	Nuclear-Trained Surface Warfare Only	• ACOL • Unemployment Rate • Nonwhite • Academy • NROTC • Dependents Status
7	Censoring Controls	Full	• ACOL • Years Since Last Decision • MSR 3 Dummy • MSR 4 Dummy
8	Alternative Unemployment Measure	Full	• ACOL • Median Duration of Unemployment (weeks)

[8]Parameter estimates for each specification are included in Appendix A.

Pay Effects

Pay responsiveness did not vary greatly across the specifications. Estimates based on a permanent 10 percent increase in RMC yielded implied elasticities ranging from 0.37 to 0.61 at the first decision point.[9]

Table 6 shows the pay elasticities for a 10 percent RMC increase by specification and decision point. Pay elasticities also decline consistently with tenure across all specifications. In the basic specification, pay elasticities fall by between 33 percent and 37 percent; the initial drop for the demographic specification is more dramatic (43%-49%). From the second to third decision points, elasticities fall by between 30 percent and 35 percent. For subsequent decision points, the rate slows to about 10-15 percent per decision point.

Table 6

Implied Retention-Pay Elasticities by Model and Decision Point

	Model Specification							
	Basic Model			Demographic Model			Censoring Controls	Altern. Unemp.
Dec. Point	Full 1	Sub 2	SWO 3	Full 4	Sub 5	SWO 6	7	8
1	0.498	0.510	0.503	0.489	0.493	0.611	0.465	0.370
2	0.314	0.314	0.336	0.273	0.280	0.312	0.207	0.246
3	0.209	0.205	0.234	0.182	0.182	0.211	0.140	0.167
4	0.172	0.166	0.198	0.146	0.144	0.170	0.117	0.135
5	0.144	0.138	0.170	0.120	0.117	0.140	0.100	0.110
6	0.118	0.110	0.144	0.095	0.090	0.108	0.085	0.087
7	0.097	0.089	0.122	0.076	0.070	0.084	0.072	0.069
8	0.077	0.068	0.101	0.058	0.052	0.061	0.058	0.053
9	0.088	0.082	-------	0.070	0.065	-------	0.066	0.062
10	0.067	0.060	-------	0.050	0.044	-------	0.052	0.045

[9] Generating elasticities by YCS instead of decision point is somewhat problematic, because the probability of staying at, say, LOS 11 depends to a certain extent on how many prior retention decisions were made.

Figure 2 shows the implied pay elasticities by decision point and by sample for the basic model.

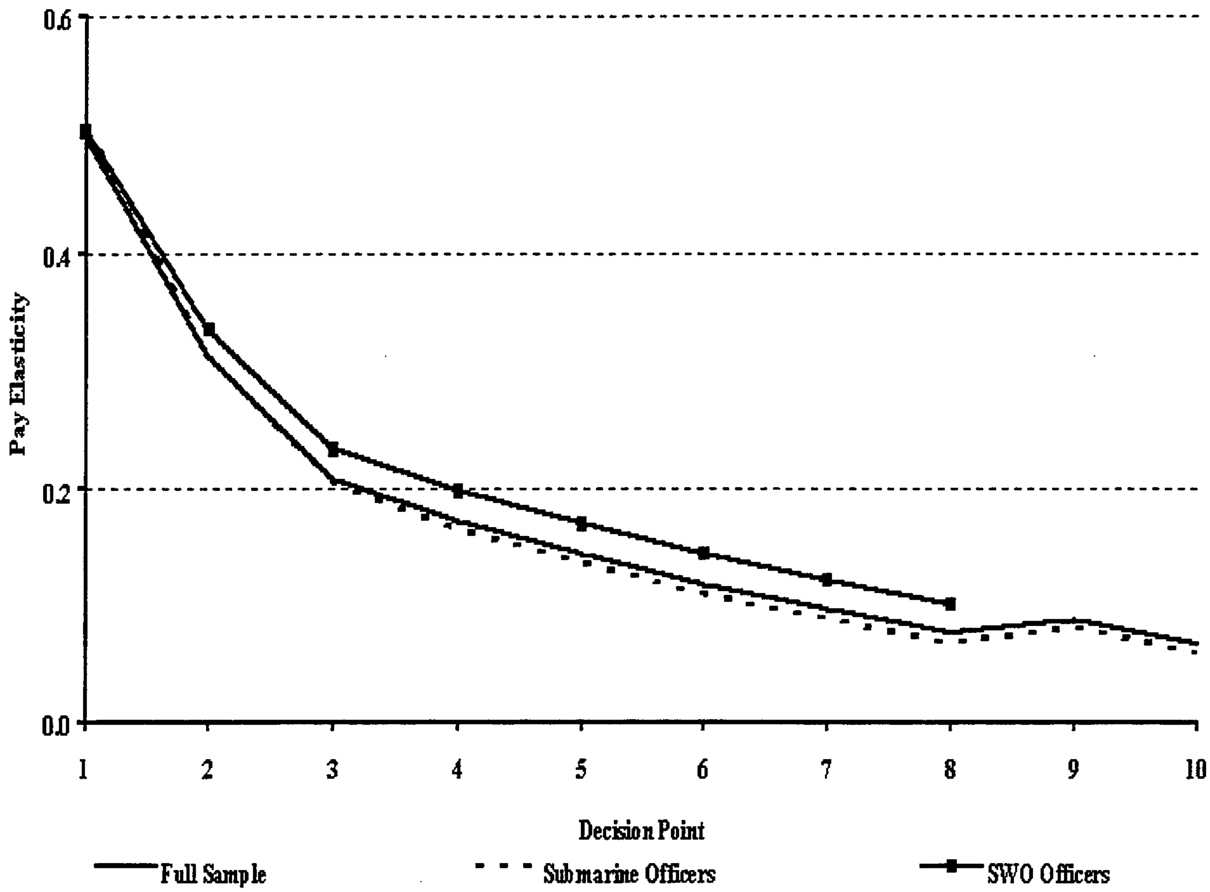

Figure 2. Simulated retention-pay elasticities for full, submarine, and SWO samples.

For the full sample and the submarine sample, adding demographic variables reduced the impact of pay, but the opposite effect occurred for the surface warfare sample. The largest decrease resulted from using the alternative unemployment measure and the censoring controls (see Table 6). Figure 3 compares the simulated elasticities for alternative specifications, all using the full sample. Adding demographic variables causes consistently smaller pay elasticities, but adding censoring controls causes a greater initial drop in pay elasticities. Note that the specification using an alternative unemployment measure produced a significantly smaller initial pay elasticity (0.370).

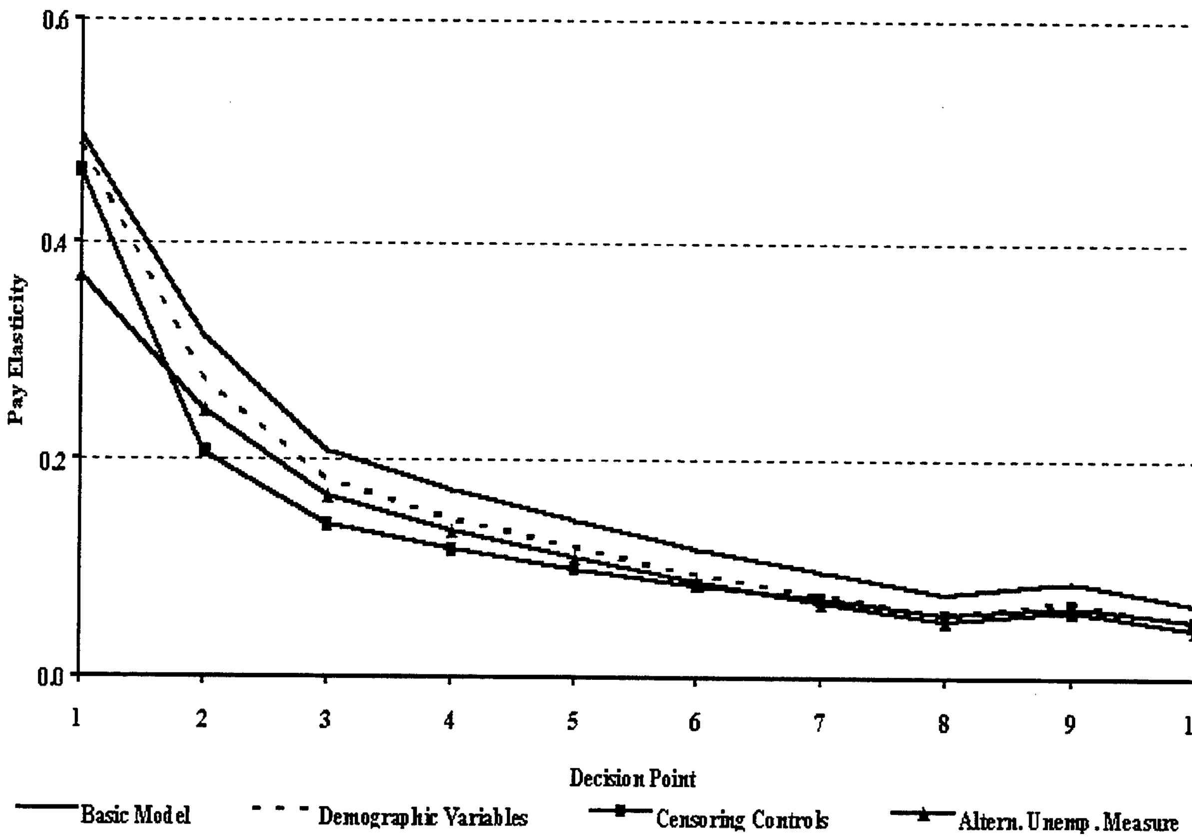

Figure 3. Simulated retention-pay elasticities for alternative specifications.

Simulated pay elasticities were also estimated based on changes in the COPAY level. COPAY accounts for a much smaller proportion of total military earnings than do the components of RMC. Not surprisingly, then, estimated pay elasticities based on a permanent, 10 percent increase in COPAY are much smaller than the equivalent, RMC-based elasticities shown above. Table 7 shows retention-bonus elasticities by decision point for specifications (4), (5) and (6).

Table 7

Implied Retention-Bonus Elasticities by Model and Decision Point

	Demographic Model		
Decision Point	**Full (4)**	**Sub (5)**	**SWO (6)**
1	0.093	0.094	0.116
2	0.049	0.050	0.056
3	0.035	0.035	0.041
4	0.023	0.023	0.027
5	0.018	0.017	0.021
6	0.011	0.011	0.013
7	0.008	0.008	0.009
8	0.006	0.005	0.006
9	0.007	0.007	-------
10	0.005	0.004	-------

Unemployment Effects

The unemployment rate generally showed a positive effect on retention, although the impact was either insignificant or significant only at the 0.10 level. For both the basic and demographic specifications, the unemployment effect was significant at the 0.05 level for the full sample only. For the both specifications, a 10 percent increase in the unemployment rate at the first decision point increases retention by about 0.4 percent. Unemployment was also significant at the 0.01 level for specification (7) (Censoring Controls). A 10 percent increase in the unemployment rate at the first decision point increases retention by about 1.1 percent.

Estimates using the alternative unemployment measure were significant, but in the opposite direction from the hypothesized effect. Specification (8) predicts that an increase in the median duration of unemployment *decreases* the probability of staying. One possible explanation of this counter-intuitive result is that the duration measure has some counter-cyclical effects.

Censoring Controls

The correlation coefficient (ρ) was positive and statistically significant at the 0.05 level or better for every specification except specification (3), Surface Warfare Basic Model. Adding demographic variables reduced the magnitude of ρ slightly. Also, the correlation coefficient was highest for the SWO sample (0.37 in the demographic specification, compared to 0.20 for the full sample and 0.13 for the Submarine sample). Using additional *ad-hoc* controls for the varying length of time between decisions did not produce sensible results. As expected, adding these controls in specification (7) reduced the value of ρ (from 0.20 to 0.13 for the full sample), but the years since last decision showed a positive effect. That is, the longer it had been since a decision, the more likely that an officer would stay. This may in fact be a measure of prior selection regarding COPAY (those who selected longer obligations signaled a higher taste for military service).

Demographic Effects

Source of commission variables were significant for the full sample and the Submarine sample (specifications (4) and (5)). In each, Academy and NROTC graduates were more likely to stay than the omitted group. Those with dependents were more likely to stay in all three samples, and nonwhites were less likely to stay.

Model Simulation for Policy Applications

The primary purpose of this research is to determine the cost-effectiveness of the Nuclear Officer Incentive Pay program. Accordingly, the retention equation results were used to predict changes in Nuclear officer retention behavior that would result from changes in Nuclear officer incentive pay.

Several policy options were examined in the course of the analysis. This report includes a representative sample of the alternatives examined. The remainder of this section explains the methodology used and summarizes the retention effects predicted.

Analytical Approach

Retention effects were predicted using a "delta" approach. That is, in each case we calculated baseline ACOL values in FY 1994 for "typical" nuclear officers at each decision point.[10] Baseline continuation rates were provided by PERS-211N for both Submarine and SWO Nuclear officers. Examination of policy effects was restricted to officers having between 4 and 15 YCS. Each alternative was examined separately for Submarine and SWO officers. The new continuation rates (CR_1) are based on the change in ACOL ($ACOL_1 - ACOL_0$) resulting from the alternative COPAY/AIB and the baseline retention rate:

$$CR_1 = \Phi[\Phi^{-1}(CR_0) + \beta_{ACOL}(ACOL_1 - ACOL_0)] \,, \qquad (24)$$

where CR_0 is the baseline continuation rate; β_{ACOL} is the coefficient on ACOL; Φ represents the cumulative normal distribution function; and Φ^{-1} represents the inverse of the cumulative normal distribution function (or probit index).

[10] A "typical" officer was constructed using the modal or median characteristics of the personal and service-related attributes used to calculate an ACOL value.

Specifications (5) and (6)—Submarine Demographic and SWO Demographic—were used for the policy-analysis examples included here. These models included demographic and service-related explanatory variables, as well as ACOL and the national unemployment rate.

One important constraint imposed by the structure of the ACOL model, however, is that in all of the scenarios examined here, marginal changes in AIB levels have no measurable impact. Unless AIB increases above the level of COPAY, the maximum ACOL horizon will include a COPAY obligation. Therefore, we only discuss COPAY changes in the discussion below.

Policy Scenarios

We looked at the following potential changes in Nuclear Officer Continuation Pay:

1. Increase COPAY level by 20 percent (from \$10,000 to \$12,000).

2. Decrease COPAY level by 20 percent (from \$10,000 to \$8,000).

3. Pay an initial COPAY contract of \$15,000/year, followed by subsequent contracts of \$12,000/year.

4. Pay an initial COPAY contract at MSR for \$20,000/year with no subsequent contracts.

For the third and fourth policy scenarios, we assumed that an officer could take an initial contract for 5 years at MSR. Other alternatives examined varied only in the amount of the increase or decrease in the amount paid per year.

Retention Effects

ACOL analysis of COPAY alternatives resulted in changes in the expected direction. Table 8 summarizes the predicted effects. A 20 percent increase in COPAY increases Submarine officer continuation at YCS 4 by about 2.4 percent; a similar increase raises SWO continuation by about 4.0 percent. Continuation gains generally decline with tenure, particularly as continuation rates exceed 0.9 percent. Continuation rate changes are nearly symmetrical for a 20 percent decrease in COPAY—i.e., the decreases in continuation rates are equal (in the opposite direction) to the increases resulting from a COPAY raise.

When the initial contract is for \$15,000/year, followed by contracts at \$12,000/year, the initial gains in continuation are more dramatic. For Submarine officers, continuation rates increase between 0.6 percent and 4.2 percent, while SWO continuation rates increase by between 0.5 percent and 7.1 percent. Initial continuation rates are increased most by single contract scenario, in which Nuclear officers may only receive one 5-year contract at \$20,000/year. At YCS 4, Submarine continuation rates increase by 6.8 percent and SWO continuation rates increase by 14.1 percent. Because no subsequent COPAY is available, continuation rates begin to drop dramatically at YCS 10. Submarine officer continuation rates fall by 12.7 percent and SWO continuation rates fall by 5.0 percent.

Another measure of effectiveness for COPAY alternatives is the proportion of officers observed at YCS 4 who remain in the Navy at the end of YCS 10. Figure 4 compares cumulative continuation rates (calculated as the product of continuation rates for YCS 4 through YCS 10) for the baseline case and each COPAY alternative. The third alternative (initial contract at $15,000/year) resulted in the biggest increase in survival rates for both Submarine and SWO officers-Submarine survival rates increased from 18.3 percent to 21.6 percent, and SWO rates rose from 17.6 percent to 21.3 percent. A one-time COPAY contract at $20,000/year increases SWO cumulative rates but actually causes Submarine rates to fall slightly.

Table 8

Predicted Impact of COPAY Alternatives on Nuclear Officer Continuation

YCS	Baseline Cont. Rate	20% Increase		20% Decrease		$15,000/12,000		$20,000 (One Time)	
		Cont. Rate	Change	Cont. Rate	Change	Cont. Rate	Change	Cont. Rate	Change
Submarine Officers									
4	0.684	0.700	2.4%	0.667	-2.4%	0.713	4.2%	0.730	6.8%
5	0.865	0.875	1.1%	0.855	-1.2%	0.881	1.9%	0.890	2.9%
6	0.732	0.747	2.1%	0.717	-2.1%	0.756	3.2%	0.764	4.4%
7	0.721	0.736	2.1%	0.705	-2.2%	0.743	3.1%	0.733	1.7%
8	0.922	0.929	0.7%	0.915	-0.8%	0.931	1.0%	0.904	-1.9%
9	0.937	0.943	0.6%	0.931	-0.6%	0.944	0.7%	0.914	-2.5%
10	0.680	0.686	0.9%	0.673	-1.0%	0.696	2.4%	0.593	-12.7%
11	0.882	0.891	1.0%	0.873	-1.1%	0.891	1.0%	0.830	-5.9%
12	0.939	0.944	0.6%	0.933	-0.6%	0.944	0.6%	0.906	-3.5%
13	0.904	0.912	0.8%	0.896	-0.9%	0.912	0.8%	0.858	-5.0%
14	0.850	0.861	1.2%	0.839	-1.3%	0.861	1.2%	0.790	-7.1%
15	0.788	0.801	1.7%	0.774	-1.7%	0.801	1.7%	0.715	-9.3%
Surface Warfare Officers									
4	0.504	0.524	4.0%	0.484	-4.0%	0.540	7.1%	0.575	14.1%
5	0.713	0.730	2.4%	0.695	-2.5%	0.742	4.0%	0.763	7.0%
6	0.824	0.837	1.6%	0.810	-1.6%	0.844	2.4%	0.851	3.3%
7	0.855	0.866	1.3%	0.843	-1.4%	0.871	1.9%	0.864	1.0%
8	0.858	0.869	1.3%	0.846	-1.4%	0.873	1.8%	0.828	-3.5%
9	0.882	0.892	1.1%	0.872	-1.2%	0.894	1.3%	0.842	-4.6%
10	0.917	0.925	0.8%	0.909	-0.9%	0.925	0.8%	0.871	-5.0%
11	0.908	0.916	0.9%	0.899	-1.0%	0.916	0.9%	0.858	-5.5%
12	0.875	0.885	1.2%	0.864	-1.2%	0.885	1.2%	0.815	-6.9%
13	0.923	0.930	0.8%	0.915	-0.8%	0.930	0.8%	0.879	-4.8%
14	0.957	0.961	0.5%	0.952	-0.5%	0.961	0.5%	0.928	-3.0%
15	0.894	0.903	1.0%	0.884	-1.1%	0.903	1.0%	0.840	-6.1%

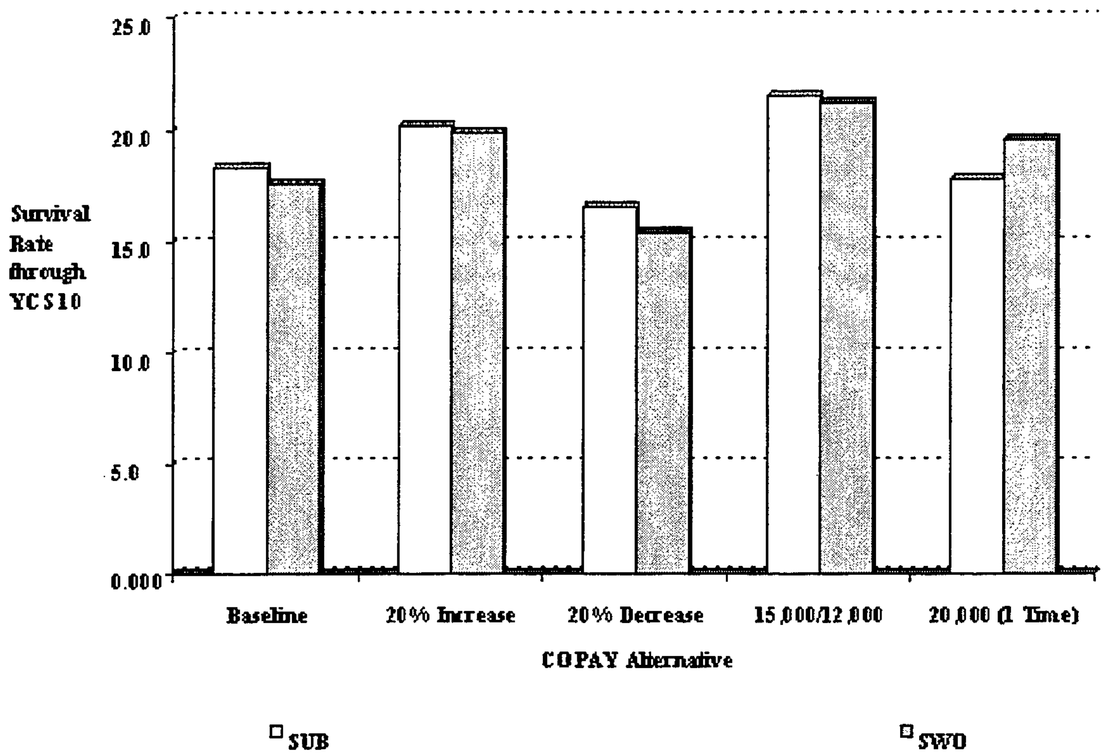

Figure 4. Predicted survival rates through YCS 10 under COPAY alternatives.

Conclusions

The pay effects observed for Nuclear program officers are relatively small, yet positive and statistically significant. The research conducted here demonstrates that the Nuclear Officer Incentive Program has had a demonstrable, positive impact on Nuclear Officer retention. That impact appears to be strongest across the earliest part of an officer's career—i.e., YCS 6-11.

Estimated pay elasticities are consistent with previous studies of officer retention behavior. For this study, pay elasticities at the initial decision point range from 0.370 to 0.611, while other studies report elasticities in the range 0.3 to 1.7. The most recent officer studies, pertaining to Army officers, also used an ACOL-2 technique, and yielded the results closest to this research. Elasticities based on changes in COPAY are much lower, which is an expected result of the smaller portion of total career military earnings they comprise relative to RMC. Retention-bonus elasticities at the initial decision point ranged from 0.09 to 0.12.

Unemployment effects were not particularly strong, and were not statistically significant at the 0.05 level in most cases. Positive, significant unemployment coefficients were observed only for the full sample. In these equations, a 10 percent increase in the national unemployment rate results in a predicted 0.4 percent increase in retention.

Application of the demographic-model estimates to alternative NOIP strategies revealed reasonable findings. Alternatives featuring higher initial contract annuities with subsequent, albeit smaller, annuities result in the largest gains in retention through YCS 10.

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Appendix A

Detailed Model Results

Table A-1

Basic Model Specification Results

Variable	Full Sample (1)	Specification Submarine (2)	Surface Warfare (3)
Intercept	-0.126780***	-0.129770	-0.276874
ACOL	0.000026*	0.000028*	0.000023*
Unemployment	0.015405**	0.013362***	0.032958***
ρ	0.242331*	0.167901*	0.483785
Likelihood Ratio (χ^2)	3,969.66*	3,485.99*	840.95*

* Significant at the 0.01 level.
** Significant at the 0.05 level.
*** Significant at the 0.10 level.

Table A-2

Demographic Model Specification Results

Variable	Full Sample (4)	Specification Submarine (5)	Surface Warfare (6)
Intercept	-0.267628*	-0.266443*	-0.552079
ACOL	0.000028*	0.000029*	0.000032*
Unemployment	0.015106**	0.013158***	0.040226**
Nonwhite	-0.282381*	-0.244341*	-0.527814*
Academy	0.161887*	0.166143*	0.084345***
NROTC	0.077727*	0.103139*	-0.080238
Dependents Status	0.075362*	0.050918*	0.160742*
ρ	0.201205*	0.133269*	0.368786**
Likelihood Ratio (χ^2)	5,716.37*	4,892.09*	1,598.03*

* Significant at the 0.01 level.
** Significant at the 0.05 level.
*** Significant at the 0.10 level.

Table A-3

Alternative Model Specification Results

Variable	Specification: Censoring Controls (7)	Specification: Alternative Unemployment Measure (8)
Intercept	-0.232445*	0.249432*
ACOL	0.000023*	0.000026*
Unemployment	0.036707*	-------------
Unemployment Duration	-------------	-0.031357*
MSR 3	1.615016*	-------------
MSR 4	-0.169741*	-------------
Years Since Last Decision	0.204517*	-------------
ρ	0.129583*	0.267852*
Likelihood Ratio (χ^2)	5,596.11*	1,057.32*

* Significant at the 0.01 level.
** Significant at the 0.05 level.
*** Significant at the 0.10 level.

Appendix B

Annualized Cost of Leaving (ACOL)

Annualized Cost of Leaving (ACOL)

The most important explanatory variable in the model is the return to the occupation, or earnings. In theory, ACOL equals the difference between expected military earnings and alternative civilian earnings (M - C) and the value of the non-pecuniary factors affecting retention, including the "taste" component. For the estimation model, however, tastes appear implicitly in the error term. Thus, the ACOL variable used here includes two elements: military and civilian earnings.

The economic theory of human capital implies that individuals choose a course of action that maximizes the net present value of returns over their remaining working lives. This concept has implications for determining the appropriate horizon for considering a job change. In other words, an individual will not change jobs to achieve a higher immediate wage if the net present value of returns over his/her lifetime is lowered, holding non-pecuniary differences constant.

The model is normalized by expressing returns as the difference between the returns to staying in the military and the returns to leaving immediately (hence, the "cost of leaving"). The pay variable is the difference between expected lifetime earnings if the individual stays until some optimal horizon and expected earnings if he/she leaves immediately. The determination of optimal horizon is discussed below.

The ACOL model is sometimes referred to as a "maximum regret" model.[1] It assumes that an individual will leave immediately only if $M_j - C_j < -Z\beta + \alpha_j + \varepsilon_{j,t}$ for each $j = 1,2,\ldots,30$ - YCS. This implies that an officer will stay if there is at least one horizon for which the returns to staying exceed the returns to leaving. The ACOL variable is defined as the maximum pay difference over all possible horizons.[2]

To calculate the ACOL variable, assume that an officer can stay in the military for a maximum of n more years, and will stay in the labor force T more years, regardless of when he leaves the Navy.[3] Then, the following variables can be calculated for n possible horizons:

1. M_k = expected military pay in year k ($k = 1,2,\ldots,n$).

2. C_{k0} = future potential civilian earnings from leaving immediately ($k = 1,2,\ldots,T$).

3. C_{kn} = future potential civilian earnings from staying n more years, where civilian wages are conditional on n years of military experience ($k = n + 1, n + 2,\ldots,T$).

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[1]Arguden (1986), p. 30.

[2]Warner and Goldberg (1984), pp. 14-15. Note that the ACOL measure should be considered an index describing the financial incentive to stay at least one more year. The horizon associated with the maximum ACOL value is not necessarily the optimal leaving point.

[3]This specification of the pay variable is derived from Warner and Goldberg (1984), p. 27.

4. r = the personal discount rate.

5. $d^k = (1/(1+r))^k \; (k = 1,...,T)$.

One key to correctly specifying the model for nuclear officers is including the proper elements in the military pay stream. For horizons beyond MSR of one or two years, military pay, M_k, includes Regular Military Compensation (RMC) and annual AIB. For horizons beyond MSR of 3 years or more, M_k includes RMC, military retirement (if horizon YCS > 20) and COPAY. Submarine officers were assumed to receive submarine pay.

Expected military pay was constructed using historical pay tables covering the period of analysis and deflated into FY 1988 dollars. For each year, Regular Military Compensation (RMC) was calculated for each YCS and paygrade combination for officers with and without dependents using all-DoD cash averages for Variable Housing Allowance and all-cash amounts for Basic Allowance for Quarters and Basic Allowance for Subsistence. RMC was collapsed into an YCS average using the distribution of nuclear officers across paygrades for each YCS. Finally, the Consumer Price Index for Urban Wage Earners (CPI-U) was used to inflate or deflate each year's RMC numbers into FY 1988 dollars. Estimates of potential civilian earnings are derived from an experience-earnings equation estimated on a sample of full-time workers in the civilian sector and are fully described in Appendix C.

The *cost of leaving* (COL_n) is the discounted stream of pay differences over the T-year horizon:

$$COL_n = \sum_{k=1}^{n} M_k d^k + \sum_{k=n+1}^{T} W_{kn} d^k - \sum_{k=1}^{T} W_{k0} d^k . \quad (1)$$

Rearranging terms,

$$COL_n = \sum_{k=1}^{n} d^k (M_k - W_{k0}) + \sum_{k=n+1}^{T} d^k (W_{kn} - W_{k0}) . \quad (2)$$

Finally, the pay variable must account for the fact that the present value of pay received decreases with distance from the decision point. Thus, the annualized pay difference ($ACOL_n$) is expressed as:

$$ACOL_n = \frac{COL_n}{\sum_{k=1}^{n} d^k} . \quad (3)$$

The ACOL value used in the estimation is

$$\max_{n} \quad ACOL_n = ACOL_n^* . \tag{4}$$

where the horizon, n, maximizes the annuitized difference between military and civilian pay.

Appendix C

Civilian Earnings Function

Civilian Earnings Function

One of the most important elements of our calculation of the Annualized Cost of Leaving (ACOL) is our prediction of the earnings that officers expect to earn in the private sector should they leave the Navy. We are always hampered by an asymmetry in the amount of information we have about civilian and military earnings. Past studies have used general samples of civilian workers and veterans-based samples to estimate earnings equations.

Veterans' data has been pursued for a number of reasons. First, merely having served in the military constitutes a formidable screening mechanism. That is, those who qualify to serve and who are able to successfully serve have demonstrated qualities which we expect to be positively correlated with earnings potential in the private sector. Therefore, a sample which includes non-veterans may underpredict expected earnings.[1] The other major reason for using veteran-only samples is that such data can be linked to service-related attributes and can differentiate between the earnings effects of military and civilian experience.

While other studies have used veteran-only data sets (notably the Post Service Earnings History File), the existing data in this area is somewhat dated, and in some cases hampered by data restrictions imposed by privacy concerns. We have attempted to identify other data sources as a substitute. In this paper we have used a cross-sectional sample from the Census Bureau's 1990 *Public Use Microdata Samples* (PUMS). The data set includes information for a representational cross-section of the population on civilian income and wage earnings and also on a wide range of demographic attributes such as education, gender, occupation and age. PUMS is a 5 percent sample from the 1990 Decennial Census; unlike other Census Bureau data sets (such as the CPS) it contains an entry for years of active military service. Thus, the PUMS data permitted us to tailor our civilian extract to include only veterans. In so doing, we created a mechanism whereby the differential impact that military and civilian experience have on earnings can be measured.

The PUMS data contain information on years of active-duty service, allowing the earnings equation to differentiate between military and civilian experience. The specification used in the ACOL calculation estimated the earnings for male, college graduates in engineering and managerial occupations. The estimated parameters were used in combination with the officer's characteristics, the horizon years of military experience and civilian experience to project earnings from the point at which the officer leaves the Navy until retirement. The earnings projections were deflated from 1989 dollars (the year to which earnings estimates correspond) to 1988 dollars using the CPI-U. Then, median weekly earnings by age group from the Census Bureau's Current Population Survey (CPS) were used to construct an index of real-wage growth across the period of analysis. The index for the appropriate analysis year was used to adjust projected civilian earnings.

We have tested two different approaches to estimating civilian-earnings equations. In the first approach we limit our sample merely by testing for veteran status and workforce participation. In the second approach we restrict our sample to workers in occupations that we believe may be

[1]Conversely, a sample of veterans may differ in earnings potential from a sample of individuals who chose to remain in the military. One could argue that those whose civilian earnings opportunities were best leave earlier; thus a veterans' sample may in fact overstate earnings expectations.

representative of the opportunity set facing nuclear officers. Our analysis included five separate specifications as reported below.

Occupation-General Approach

The initial extract is a random sample of individuals who had reported at least 1 year of military service. It includes 13,892 records. Veterans who were not full-time members of the labor force and between the ages of 17 and 65 were excluded, resulting in a final sample of 7,792 records. This restriction may create some upward bias on earnings estimates since, in reality, some individuals are in school or unemployed immediately after service. However, removing this transitory component allows the focus to be placed on permanent earnings potential. All occupational groups were included in this sample (Table C-1).

Table C-1

Variable Means and Standard Deviations of Sample One

Variable	Mean	Standard Deviation
Log of Earnings	10.1405	0.8115
Exper (M)	4.0311	3.9913
Exper (C)	23.9487	11.1326
Female	0.0345	0.1825
Nonwhite	0.1243	0.3299
High School	0.5790	0.4937
Some College	0.0838	0.2771
Bachelors	0.1406	0.3476
Bachelors Plus	0.0842	0.2777

We estimated two specifications using this approach (Tables C-2 and C-3). In each, the earnings equation is a quadratic expression containing military experience terms measured in YCS and civilian experience terms calculated as the "typical" time duration since separation from the military (age - years of education - 5 - military YCS). A military/civilian experience interaction term is also included.

The first specification regresses the natural logarithm of earnings on the experience variables and on gender, race (white or nonwhite) and a set of variables measuring the effect of additional levels of education completed. The second specification adds occupational variables.

Table C-2

Parameter Estimates for Civilian Earnings Equation (1)

Variable	Estimate	t-ratio
Intercept	8.7810*	144.827
Exper (M)	0.0958*	9.043
$Exper^2$ (M)	-0.0023*	-6.750
Exper (C)	0.0766*	19.214
$Exper^2$ (C)	-0.0012*	-16.338
Exper (C*M)	-0.0027*	-7.858
Female	-0.5278*	-9.020
Nonwhite	-0.1879*	-7.314
High School	0.2223*	8.533
Some College	0.3566*	9.641
Bachelors	0.5932*	17.453
Bachelors Plus	0.8189*	19.192

*Significant at 1 percent level.
$R^2 = .169$.

Table C-3

Parameter Estimates for Civilian Earnings Equation (2)

Variable	Estimate	t-ratio
Intercept	8.8555*	146.014
Exper (M)	0.0895*	8.520
$Exper^2$ (M)	-0.0022*	-6.344
Exper (C)	0.0731*	18.409
$Exper^2$ (C)	-0.0011*	-15.723
Exper (C*M)	-0.0025*	-7.573
Female	-0.5450*	-9.468
Nonwhite	-0.1706*	-6.792
High School	0.1783*	6.917
Some College	0.2706*	7.268
Bachelors	0.4393*	12.171
Bachelors Plus	0.5989*	12.616
Admin/Manage	0.2993*	11.921
Professional	0.2151*	6.948
Technical	0.2422*	7.286
Service	-0.1906*	-6.407
Farm	-0.3801*	-5.037

*Significant at 1 percent level.
$R^2 = .201$.

Occupation-Specific Approach

For the second approach, we limited the data set to people in civilian occupational categories that we consider to be alternative career choices for nuclear officers. These included both engineering and managerial type occupations. This extract contained 18,877 records (Table C-4).

Table C-4

Variable Means and Standard Deviations for Sample Two

Variable	Mean	Std. Deviation
Log of Earnings	10.5447	0.6915
Exper (M)	4.3606	4.5558
Exper (C)	24.2302	10.3839
Female	0.0215	0.1451
Nonwhite	0.0817	0.0170
High School	0.4745	0.0222
Some College	0.1017	0.0260
Bachelors	0.2475	0.0234
Bachelors Plus	0.1273	0.0251

We estimated three specifications using this approach (Tables C-5, C-6, and C-7). The first most general specification is identical to equation 1. For the second specification (equation 4), we limited our sample to males. This produced almost no effect due to the small numbers of females in our sample. For the third specification, we limited the sample to male, college graduates. This is the group that most resembles the Nuclear Officer population.

Table C-5

Parameter Estimates for Civilian Earnings Equation (3)

Variable	Estimate	t-ratio
Intercept	9.1883*	212.745
Exper (M)	0.0620*	10.457
$Exper^2$ (M)	-0.0012*	-6.807
Exper (C)	0.0701*	26.817
$Exper^2$ (C)	-0.0011*	-23.128
Exper (C*M)	-0.0020*	-11.148
Female	-0.3896*	-12.044
Nonwhite	-0.1534*	-9.007
High School	0.2161*	9.726
Some College	0.3193*	12.276
Bachelors	0.5577*	23.883
Bachelors Plus	0.6645*	24.466

*Significant at the 1 percent level.
$R^2 = 0.157$.

Table C-6

Parameter Estimates for Civilian Earnings Equation (4)

Variable	Estimate	t-ratio
Intercept	9.1679*	209.370
Exper (M)	0.0641*	10.680
$Exper^2$ (M)	-0.0012*	-6.944
Exper (C)	0.0717*	26.940
$Exper^2$ (C)	-0.0011*	-23.312
Exper (C*M)	0.0021*	-11.510
Nonwhite	-0.1693*	-9.775
High School	0.2146*	9.675
Some College	0.3208*	12.310
Bachelors	0.5568*	23.874
Bachelors Plus	0.6582*	26.247

*Significant at the 1 percent level.
$R^2 = 0.145$.

Table C-7

Parameter Estimates for Civilian Earnings Equation (5)

Variable	Estimate	t-ratio
Intercept	9.7060*	132.616
Exper (M)	0.0701*	6.740
$Exper^2$ (M)	-0.0014*	-4.843
Exper (C)	0.0785*	15.008
$Exper^2$ (C)	-0.0013*	-13.534
Exper (C*M)	-0.0025*	-7.182
Nonwhite	-0.2366*	-7.248
Bachelors Plus	0.1053*	6.204

*Significant at the 1 percent level.
$R^2 = 0.064$.

In all five specifications, the income returns to both types of experience, military and civilian, are significant and substantial. The negative coefficient on the squared experience terms indicates that earnings profiles are concave—they increase at a decreasing rate in YCS space.

The coefficient on the military/civilian experience interaction term is significant and negative. This, too, conforms with previous findings and is consistent with life-cycle investment theory which argues that there is less incentive, for both employers and employees, to develop human capital for older workers.

Estimates of the returns to education are also reasonable. The greater the education level, the higher is the post-service earnings, all else held constant. The correlation is stronger in equation 1 because of the absence of any occupational variation. The smaller education coefficient in equation 5 reflects the smaller impact additional education has for college graduates in these occupational fields.

The major difference between the results from our two approaches is in the relative returns to civilian and military experience. For the general sample, the returns to military experience are higher than the returns to civilian experience; this relationship reverses for the estimates from the occupationally-specific sample. The latter result is more consistent with previous research on veterans' earnings. One possible explanation for the discrepancy in results could be that military experience is less transferable to civilian jobs in managerial and engineering fields than it is to other occupations.

The following chart represents the average annual earnings as civilian experience increases under each of the five specifications for a white male with a bachelor's degree and 5 years of military experience. The results for equations 4 and 5 are virtually identical and are indistinguishable on the chart.

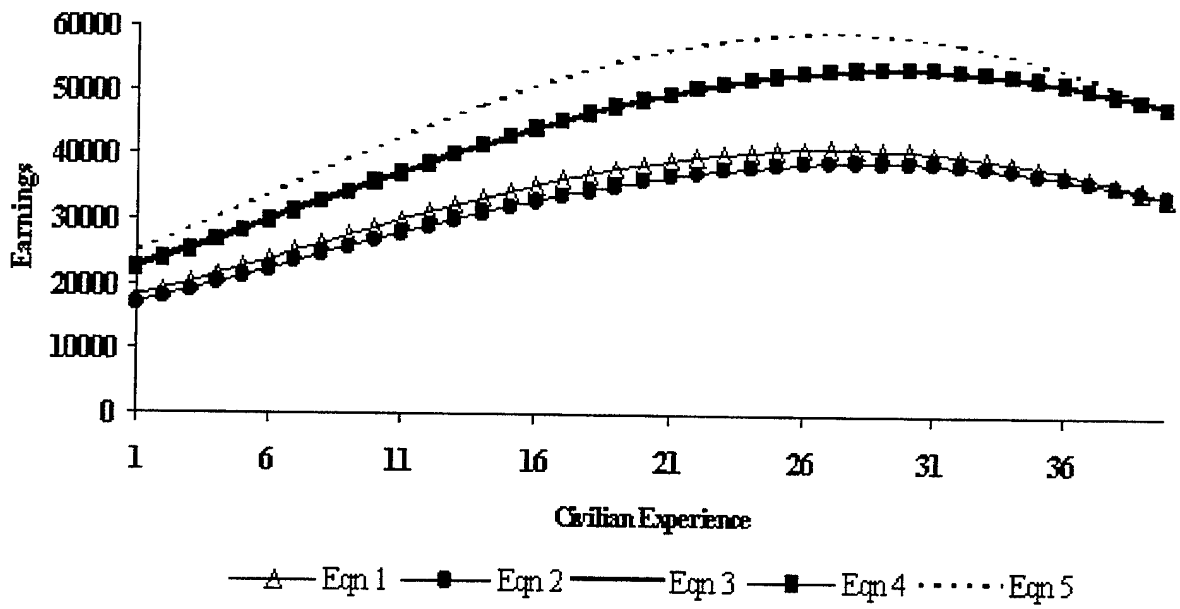

Figure C-1. Predicted earnings for a white male with a Bachelor's degree.

Distribution List

Assistant Secretary of the Navy (Manpower and Reserve Affairs (OASN) (M&RA)
Chief of Naval Personnel (PERS-00),(PERS-00B), (PERS-00H), (PERS-2), (PERS-23), (PERS-24)
Office of Naval Research (Code 01E)
Director, Army Research Institute (PERI-ZT), Alexandria, VA
Operations and Support Directorate, Armstrong Laboratory (AL/DO), (AL/HR-DOKL Technical Library), Brooks Air Force Base, TX
President, Naval War College (Code E-1121)
Superintendent, Naval Postgraduate School
Director of Research, U.S. Naval Academy
Center for Naval Analyses, Acquisition Unit
Pentagon Library
Defense Technical Information Center (4)