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Technical Report 962

A Model of U.S. Army Officer Retention Behavior

Final Report

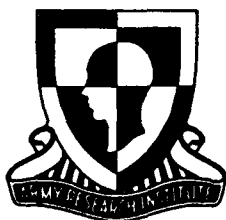
Lee S. Mairs and Patrick C. Mackin
SAG Corporation

Paul F. Hogan
Decision Systems Corporation

Robert Tinney
U.S. Army Research Institute

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EDGAR M. JOHNSON
Technical Director

MICHAEL D. SHALER
COL, AR
Commanding

Research accomplished under contract
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SAG Corporation

Technical review by

Albion A. Bergstrom
Hyder A. Lakhani
Abraham Nelson

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13. ABSTRACT (Maximum 200 words) <p>This report summarizes the findings of a pilot study of the determinants of officer retention behavior. Stay-leave decisions for a sample of Air Defense Artillery officers were modeled in an ACOL-2 (panel probit) framework. The estimation showed that the officers were sensitive to changes in civilian and military pay, as well as to the condition of the civilian labor market. Retention behavior also varies by source of commission, gender, race, and marital status. Finally, the panel probit specification confirmed that unobserved heterogeneity had a significant impact. As officer cohorts age, the distribution of unobserved tastes for the military becomes truncated and retention rates rise.</p> <p>The study also included tests of alternative specifications for the pay variable and the size of the decision window, as well as an evaluation of the applicability of model results for a policy analysis model. The model will allow Army decision makers to track the effects of changes in policy, compensation, and economic conditions on the probability that officers will stay through key career decision points. Follow-on work will include estimating the model for all officers and increasing the number of decisions modeled.</p>				
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Lee S. Mairs and Patrick C. Mackin

SAG Corporation

Paul F. Hogan

Decision Systems Corporation

Robert Tinney

U.S. Army Research Institute

Manpower and Personnel Policy Research Technical Area
Clinton B. Walker, Acting Chief

Manpower and Personnel Research Division
Zita M. Simutis, Director

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
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FOREWORD

The Manpower and Personnel Policy Research Technical Area of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research on the economics of manpower and personnel issues of particular significance to the U.S. Army. This project developed a prototype ACOL-2 econometric model of the retention decision of field-grade, active-duty officers in the Air Defense Artillery (ADA) Branch. This research is the first step in the development of a policy analysis system to evaluate changes in officer personnel policy.

ARI's participation in this effort is part of an ongoing program of research designed to enhance the quality of Army officer personnel. This work is an essential part of the mission of ARI's Manpower and Personnel Policy Research Technical Area to conduct research to improve the Army's ability to effectively and efficiently manage the force.

EDGAR M. JOHNSON
Technical Director

A MODEL OF U.S. ARMY OFFICER RETENTION BEHAVIOR: FINAL REPORT

EXECUTIVE SUMMARY

Requirement:

The U.S. Army needs to be able to determine the impact and costs of personnel policy options and changes. An officer force structure planning model improves the Army's ability to effectively and efficiently manage the officer force. Such a model provides policymakers with timely and accurate information about the impact of policy changes, including changes in end strength, number of accessions, promotion policy, compensation, and separation incentives. This type of model also projects the size and skill composition of the officer force and estimates the cost of manpower to the Army.

Procedure:

Information about the manpower costs and effects of personnel policy and other factors on the retention of high-quality active-duty commissioned officers, both for the aggregate Army and at the branch level, is critical to the development of the human resources necessary for an effective officer force. The ACOL-2 model, a dynamic structural econometric model of the decision to stay in or leave the military as an occupation, is a recent advance in military manpower research that improves the evaluation of personnel policy changes. Preliminary research focuses on the design and estimation of a prototype ACOL-2 model that evaluates the effects of personnel policy on the retention of officers in the Air Defense Artillery (ADA) Branch.

Findings:

A prototype model that predicts officer career decisions as a function of economic, demographic, and Army personnel policy (e.g., military compensation) influences was successfully estimated with longitudinal data from the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) maintained by the Officer Longitudinal Research Data Base (OLRDB). The model estimates yielded highly (statistically) significant pay and unemployment effects in the expected directions. Further, the estimates were sensitive to the specification of voluntary separation points, thereby underscoring the importance of accurately identifying and measuring such decisions.

Utilization of Findings:

This research enables the Army to extend the ACOL-2 methodology developed for the ADA Branch to other branches and functional areas and to determine the feasibility of developing a model that evaluates the costs as well as the effects of personnel policy.

A MODEL OF U.S. ARMY OFFICER RETENTION BEHAVIOR: FINAL REPORT

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A MODEL OF U.S. ARMY OFFICER RETENTION BEHAVIOR FINAL REPORT

INTRODUCTION

The U.S. Army faces a critical juncture in the management of its active-duty commissioned officers. The perceived reduction in external security threats—coupled with continuing pressure to reduce the federal budget deficit—will inevitably lead to a smaller Army officer corps in the 1990s. While the demand for active-duty officers will decline in the aggregate, individual units in a smaller force must be more flexible, capable of a wider range of tasks and operations, and less specialized to specific functions than in the past.

The irony is that in this era of "downsizing" the Armed Forces, well-reasoned retention policies that continue to make the Army attractive to high-quality, top-performing officers become more important than ever. The Army's ability to measure the performance and potential of officers, and its ability to devise retention policies and programs that keep the most talented in the Army while remaining within constrained budget ceilings, will be severely tested.

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) funded a study through the Army's Small Business Innovative Research (SBIR) program to explore the feasibility of an econometric model of Army officers' retention behavior. The model results provide evidence of the responsiveness of officers in a single branch to pay changes and economic conditions. Further, they serve as a proof of concept for the Phase II estimation of the model for a broader range of officers and decision points and the development of an officer policy planning model that provides reliable estimates of the effects of policy changes on personnel flows and manpower costs.

The Air Defense Artillery (ADA) branch served as the test population. A two-decision ACOL-2 (panel probit) retention model provided an empirical framework and used an estimation data set created from the Officer Longitudinal Research Data Base (OLRDB) maintained by ARI. ADA officers making decisions between FY79 and FY90 constituted the test sample. Finally, alternative specifications of the model test its sensitivity to changes in the size of the decision window and evaluate assumptions about relevant explanatory variables.

This report presents the results of the analysis. The major sections include

1. Theory—an overview of the model's conceptual framework
2. Economic Model—a discussion of the model's application to the problem of Army officer retention
3. Data—a description of the primary data set and a review of data issues that arose in the course of this research
4. Research Findings—the model parameters and interpretation of their effects
5. Conclusions—a summary of the major findings, their implications for policy analysis, and their relevance for further research

THEORY

Behavioral retention models estimate the effects of pay changes and economic conditions on the propensity of individuals to remain in the military. These models are grounded in the economics literature on occupational choice. Most retention studies assume a two-choice world in which an individual can choose employment in the military or employment in civilian occupations.

A crucial issue that retention models must address is the horizon problem. That is, over what horizon should two occupational alternatives be compared? The Annualized Cost of Leaving (ACOL) model provides a consistent, non-arbitrary solution to this question. Other less tractable models dynamically consider multiple horizons simultaneously.

Retention models must also account for changes in cohort behavior over time. Cohort retention rates rise with tenure for two principal reasons. First, an individual accumulates firm-specific human capital with tenure. This capital has no value to other employers; the employee would forfeit it upon quitting. Retention rates also rise with tenure simply because those who have a relatively high "taste" for Army life will tend to stay at higher rates than those who do not. That is, the underlying distribution of unobservable factors affecting retention behavior systematically changes as cohorts pass through decision points. This phenomenon is referred to as *taste censoring* or *unobserved heterogeneity* in the econometrics literature.

This section summarizes the utility-maximization model of retention decisions faced by Army officers used in this research. It begins with a brief survey of related studies and discusses the application of this approach to the retention decision of Army officers in the Air Defense Artillery (ADA) branch. Finally, the section describes the construction of the key explanatory variable—the Annualized Cost of Leaving (ACOL).

Review of the Literature

Research on retention in the Department of Defense is currently at the frontiers of economic models of occupational choice. However, there has been less research conducted on officer retention behavior than enlisted retention. Three models are prominent: the Annualized Cost of Leaving (ACOL) model; the ACOL-2 model, which is estimated as a panel probit and explicitly controls self-selection as members progress through the personnel system; and the Dynamic Retention Model (DRM) developed by Gotz and McCall (1983).

The simple ACOL model has been estimated for enlisted retention behavior in the Navy¹ and for each of the military Services in the aggregate.² Hogan and Goon (1989) also estimated a version for Air Force officers. The Gotz-McCall model was originally estimated for Air Force captains.³ It was later "calibrated" for Air Force enlisted personnel by Arguden (1986). The ACOL-2 model was estimated for both Navy and Army enlisted personnel.⁴ It has never previously been estimated for officers.⁵

Each method has strengths and weaknesses. The ACOL-2 model and the Gotz-McCall model explicitly control for unobserved heterogeneity—the self-selection that occurs as retention rates rise with tenure. Failure to control for unobserved differences may lead to biased parameter estimates. The ACOL-2 model has the advantage of being easier to estimate and use in policy simulations. This research estimates an ACOL-2 model for Army officers in the ADA branch.⁶

¹Warner and Goldberg (1984).

²Enns, Nelson and Warner (1984).

³Gotz and McCall (1983) provide the theory. The estimated parameters of the model were not published, however.

⁴Black, Hogan and Sylwester (1987) and Smith, Sylwester and Villa (1991).

⁵However, a version has been estimated for DoD civilians. See Black, Moffitt and Warner (1990).

⁶Hogan and Goon (1989) recently estimated a version of the simpler ACOL model for Air Force officers by occupational specialty, using other variables to control for censoring in the error structure, and found that these variables worked well.

Economic Model of Occupational Choice

Economic models of retention behavior assume that individuals seek to maximize utility by choosing either to stay in the Army or leave for the civilian sector. Utility, in turn, depends on pecuniary and non-pecuniary factors. Pecuniary influences consist of military pay and civilian earnings opportunities. Non-pecuniary factors include preference for military service; hardship associated with a duty station; and family separation.

Models of occupational choice predict that an individual chooses a career path to maximize the present value of future potential returns across his/her entire working life. In the context of an Army officer retention model, this framework compares an officer's expected time path of pecuniary and non-pecuniary returns if he/she stays in the Army to the corresponding expected time path of returns to leaving immediately. The ACOL model attempts to measure these effects quantitatively. Specifically, it measures the annualized net benefit of staying in the military versus leaving immediately.

Individual Utility Maximization. Economic models of occupational choice applied to military retention decisions assume that individuals rank jobs based on the pecuniary and non-pecuniary aspects of those jobs, and choose a job, or time path of jobs, that provides the greatest satisfaction or utility over the individual's lifetime.⁷

$U(\cdot)$ is the utility function that describes the individual's preferences (or values) of various job characteristics. The function typically includes measures of current and expected future military and civilian pay and measures describing the value of non-pecuniary conditions of military service (e.g., rotation frequency, hours of work). The value of the i^{th} attribute of an Army job is represented by $X_{i,A}$ and the value of the i^{th} attribute of the best civilian career opportunity is represented by $X_{i,C}$. According to this model, an individual reenlists if:

$$U(X_{1,A}, \dots, X_{n,A}) > U(X_{1,C}, \dots, X_{n,C}). \quad (1)$$

⁷See, for example, Smith, et. al., (1991); Black and Hogan (1987); Hogan and Goon (1989); and, for a review of current methods and research issues, Hogan and Black (1991).

Random Utility Model. The function $U(\cdot)$ 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. An assumption concerning an explicit functional form of the utility function is made, along with an assumption concerning an unobservable random component. For example, a linear utility function results in the following model:

Individual j will stay if and only if:

$$X_{j,A} \beta + \gamma_{j,A} > X_{j,C} \beta + \gamma_{j,C} \quad \text{or} \quad (2)$$

$$(X_{j,A} - X_{j,C})\beta > \gamma_{j,C} - \gamma_{j,A}, \quad (3)$$

where $X_{j,A}$ is a vector of characteristics associated with an Army job and $X_{j,C}$ is a vector of characteristics associated with the best civilian alternative; β is a vector of coefficients to be estimated and the γ s represent unobservable (to the researcher) aspects of the utility or satisfaction associated with Army and civilian alternatives. This difference, $\gamma_{j,C} - \gamma_{j,A}$, is represented by the variable γ_j , which is distributed over the population of potential stayers according to $f(\gamma)$.⁸ Then, the probability that individual j stays is:

$$\text{Prob}[(X_{j,A} - X_{j,C})\beta > \gamma_j] = \int_0^{(X_{j,A} - X_{j,C})\beta} f(\gamma) d\gamma. \quad (4)$$

Assume γ follows a normal distribution; then, this model would be estimated as a probit equation.

ACOL Model. 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

⁸Note that individual characteristics, assumed to be correlated with an individual's taste for various job attributes, can be included in the model, presumably reducing the dispersion of the unobserved component.

calculated over a horizon which maximizes the annualized difference. The decision rule becomes, stay at time t if and only if

$$ACOL_{j,t} + \beta X_{j,t} > \gamma_{j,t}. \quad (5)$$

ACOL-2 (Panel Probit) Formulation. The empirical definition of the simple ACOL model, derived above, does not account for unobserved heterogeneity. Because retention rates rise with tenure (see the discussion above), 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, $\varepsilon_{j,t}$:

$$\gamma_{j,t} = \alpha_j + \varepsilon_{j,t}. \quad (6)$$

The decision rule, ignoring other X s, becomes stay if and only if:

$$\varepsilon_{j,t} > -ACOL_{j,t} - \alpha_j. \quad (7)$$

Assume that $\varepsilon_{j,t} \sim N(0, \sigma_\varepsilon)$ and its cumulative distribution is denoted by $F(\varepsilon_{j,t})$. Further, assume that $\alpha_j \sim N(\mu_\alpha, \sigma_\alpha)$ with a cumulative distribution denoted by $G(\alpha_j)$.

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 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 distribution $f(\varepsilon_{j,t})$ —this value of ε 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 $g(\cdot)$. An officer cohort's distribution of α s changes as officers pass through multiple decision points. Those with relatively greater

preferences for Army service (higher α_s) will tend to stay at higher rates.

In particular, the probability that individual j stays at time t is:

$$\begin{aligned} p(t) &= \text{Prob}[-ACOL_{j,t} - \alpha_j < \varepsilon_{j,t}]. \\ &= \int_{-ACOL_{j,t} + \alpha_j}^{\infty} dF(\varepsilon_{j,t}) = F[ACOL_{j,t} + \alpha_j], \end{aligned} \quad (8)$$

because of the symmetry of the normal distribution of ε .

The probability that an entering officer survives through at least T decision points is

$$S_T = \prod_{t=1}^T p(t) = \prod_{t=1}^T F[ACOL_{j,t} + \alpha_j]. \quad (9)$$

For a cohort, the survival rate through T decision points is:

$$S_T = \int \left\{ \prod_{t=1}^T F[ACOL_{j,t} + \alpha_j] \right\} dG(\alpha_j). \quad (10)$$

Assume that

$$\alpha_j \sim N(\mu_\alpha, \sigma_\alpha). \quad (11)$$

Then,

$$g = \frac{(\alpha - \mu_\alpha)}{\sigma_\alpha} \quad (12)$$

is a standard normal random variable with cumulative density $N^*(g)$, and $\alpha = \sigma_\alpha g + \mu_\alpha$.

Because $\varepsilon_{j,t}$ is distributed normally, $\varepsilon_{j,t}/\sigma_\varepsilon$ is also a standard normal random variable. Finally, let X be a vector of all other factors affecting retention behavior (e.g., civilian unemployment rates, personal characteristics) with a vector B of parameters to be estimated. Making substitutions and suppressing individual subscripts, the equation for S_T is rewritten as:

$$\begin{aligned}
 S_T &= \int \left\{ \prod_{t=1}^T \left[\frac{F(ACOL_{j,t} + \sigma_\alpha g + \mu_\alpha + BX)}{\sigma_\varepsilon} \right] \right\} dN^*(g). \\
 &= \int \left\{ \prod_{t=1}^T F[\beta_1 + \beta_2 ACOL_{j,t} + \beta_3 g + \beta_4 X] \right\} dN^*(g), \tag{13}
 \end{aligned}$$

where

$$\beta_1 = \frac{\mu_\alpha}{\sigma_\varepsilon}; \quad \beta_2 = \frac{1}{\sigma_\varepsilon}; \quad \beta_3 = \frac{\sigma_\alpha}{\sigma_\varepsilon}; \quad \text{and} \quad \beta_4 = \frac{B}{\sigma_\varepsilon}.$$

The retention rate for a cohort at any given decision point, t , is S_t/S_{t-1} .

Define the correlation coefficient, ρ , as

$$\rho = \frac{\sigma_\alpha^2}{\sigma_\alpha^2 + \sigma_\varepsilon^2}. \tag{14}$$

Then,

$$\left(\frac{\rho}{1 - \rho} \right)^{1/2} = \frac{\sigma_\alpha}{\sigma_\varepsilon} = \beta_3. \tag{15}$$

The coefficient β_3 in the expression for S_T measures the relative importance of transitory versus permanent unobserved factors in explaining retention patterns. When $\rho = 0$, there is no "permanent" taste component. Unobserved heterogeneity is not a major problem and one can model retention decisions over time as independent events. The ACOL-2 or panel probit formulation is not necessary.

As ρ approaches unity, the permanent component becomes increasingly important. Since ACOL values (the cost of leaving) tend to rise with YOS because of the retirement system, retention rates approach unity rapidly after the first decision point. Controlling for unobserved heterogeneity or "tastes" becomes increasingly important in a multiple-decision framework because of the importance of this selection process.

Failure to adjust for this results in inconsistent coefficients on key variables like pay.

Calculation of the ACOL Variable

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 "taste" factor. For the estimation model, however, tastes appear implicitly in the error term. For our purposes, the ACOL variable 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.

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 often referred to as a *maximum regret* model.⁹ It assumes that an individual will leave immediately only if $M_j - C_j \leq -BX + \alpha_j + \varepsilon_{j,t}$ for each $j = 1, 2, \dots, 30 - YOS$. 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.¹⁰

⁹Arguden (1986), p. 30.

¹⁰Warner and Goldberg (1984), pp. 14-15. Note that the ACOL measure is an index function only. The horizon associated with the maximum ACOL value is not necessarily the optimal leaving point.

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/she leaves the Army.¹¹ Then, calculate the following variables for n possible horizons:

1. M_j = expected military pay in year j ($j = 1, 2, \dots, n$).
2. W_{j0} = future potential civilian earnings from leaving immediately ($j = 1, 2, \dots, T$).
3. W_{jn} = future potential civilian earnings from staying n more years ($j = n+1, n+2, \dots, T$).
4. r = the personal discount rate.
5. $d^j = \left[\frac{1}{1+r} \right]^j$ ($j = 1, 2, \dots, T$).

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

$$C_n = \sum_{j=1}^n M_j \cdot d^j + \sum_{j=n+1}^T W_{jn} \cdot d^j - \sum_{j=1}^T W_{j0} \cdot d^j. \quad (16)$$

Rearranging terms,

$$C_n = \sum_{j=1}^n d^j (M_j - W_{j0}) + \sum_{j=n+1}^T d^j (W_{jn} - W_{j0}). \quad (17)$$

This specification is valid for a generic specification of civilian earnings. The model that predicts civilian earnings in this research does not distinguish military from civilian experience in predicting future civilian earnings. Thus, $W_{j0} = W_{jn}$ and the last term drops out:

$$C_n = \sum_{j=1}^n d^j (M_j - W_{j0}). \quad (18)$$

¹¹This specification of the pay variable is derived from Warner and Goldberg (1984), p. 27.

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 (A_n) is expressed as:

$$A_n = \frac{C_n}{\sum_{j=1}^n d^j}. \quad (19)$$

The ACOL value used in the estimation is $\max_n A_n = A_n^*$.

ECONOMETRIC MODEL

This section describes how the ACOL-2 model is applied to the problem of Army officer retention in this research. It describes the maximum likelihood equations and discusses the construction of the dependent and explanatory variables in the estimation model.

The model of officer voluntary stay-leave decisions includes two decision points; decision i is represented by a latent variable (y_i^*) that is a function of a vector of explanatory variables (X_i) and a set of parameters across decision points (β):¹²

$$y_i^* = \beta'X_i + \varepsilon_i, \quad (20)$$

where ε_i is an error term.¹³ Assume that the error terms are distributed normally with means of zero and unit variances:

$$\begin{aligned} E[\varepsilon_1] &= E[\varepsilon_2] = 0, \\ \text{Var}[\varepsilon_1] &= \text{Var}[\varepsilon_2] = 1, \text{ and} \\ \text{Cov}[\varepsilon_1, \varepsilon_2] &= \rho. \end{aligned} \quad (21)$$

The ACOL-2 model used in this research is thus specified as a bivariate probit.

¹²The model is derived from the bivariate probit model presented in Greene (1990), pp. 689-693.

¹³The standard bivariate probit model presented in Greene (1990) allows the equation parameters to vary across decisions. The economic theory developed above, however, assumes that the parameters are constant across decisions (i.e., the same factors affect the stay-leave choice at each point).

Practically speaking, one cannot observe the y^* 's. Individuals are observed to either stay or leave. Thus, the observed dependent variable (y_1) equals 1 if an officer stays and equals 0 if the officer leaves. In addition, define $y_2 = 0.5$ when the second decision is censored ($y_1 = 0$) or unobserved in the data set.¹⁴

Four different outcomes are possible with this specification. An officer may (a) leave at the first decision point; (b) stay at the first decision but be unobserved at the second decision; (c) stay at the first decision and leave at the second decision; or (d) stay at both decision points.

The probability that case i will occur is expressed as:

$$Pr_i = \Phi_B(w_1, w_2, \rho^*), \quad (22)$$

where Φ_B denotes the cumulative bivariate normal distribution:

$$\Phi_B = \int_{-\infty}^{w_2} \int_{-\infty}^{w_1} \left[\frac{e^{-(w_1^2 + w_2^2 - 2\rho^* w_1 w_2)/2(1-\rho^{*2})}}{2\pi(1-\rho^{*2})^{1/2}} \right] dw_1 dw_2. \quad (23)$$

and

$$q_1 = 2y_1 - 1;$$

$$z_1 = \beta' x_1;$$

$$w_1 = q_1 \cdot z_1;$$

$$\rho^* = q_1 \cdot q_2 \cdot \rho.$$

Thus, ρ^* is zero for any case in which q_2 is zero (i.e., when $y_2 = 0.5$).

¹⁴This convention merely allows one to treat censored observations identically to two-period observations without changing the likelihood function. Setting the dependent variable to 0.5 reduces the bivariate probit model to a simple probit model.

Table 1 summarizes the values of the transformed variables for possible retention-decision outcome.

Table 1
Transformed Variables by Decision Case

Case	Y ₁	Y ₂	q ₁	q ₂	w ₁	w ₂	ρ*
a	0	0.5	-1	0	$-\beta' x_1$	0	0
b	1	0.5	1	0	$\beta' x_1$	0	0
c	1	0	1	-1	$\beta' x_1$	$-\beta' x_2$	$-\rho$
d	1	1	1	1	$\beta' x_1$	$\beta' x_2$	ρ

Estimation Model

The objective of this research is to conduct a prototype analysis of U.S. Army officer retention. The project focused on one branch—Air Defense Artillery. Specifying an empirical model for the analysis required resolution of three issues:

- officer branch to model
- definition of decision points, or windows
- length of decision window

Each decision was crucial for providing information about how well the ACOL-2 approach may apply in a broader context.

The Air Defense Artillery (ADA) branch was selected as the officer branch for this research. Preliminary data analysis revealed sufficient time-series and cross-sectional variation in separations to allow estimation of pay and other effects. In addition, the ADA branch is the only combat arms branch that accepts women. Information about the retention of female officers in a combat arms branch will be important as the Army re-examines the role of women in combat.

Army officers' career experiences are the outcome of a professional development process in which retention (i.e.,

labor supply) decisions are made by officers and performance-based promotion (i.e., labor demand) decisions are made by the Army. The first point at which an officer may make a voluntary stay/leave decision is at his/her expiration of obligated service. In principle, separation may occur at any time from this point to the maximum retirement age. In practice, however, the financial incentives of the military retirement system cause separation rates after the twelfth year of service (and selection to Major) to fall towards zero.¹⁵ An examination of loss records showed a large number of officers left the Army in year twelve. These separations occurred largely among Captains who were not selected for Major. It seems likely that separations in the twelfth year of an officer's career are due to demand conditions (e.g., personnel policy) rather than voluntary supply decisions.¹⁶ Consequently, the analysis focuses on behavior between the end of an officer's initial obligation and his/her eleventh year.

This period may span from six to nine years, because an officer's initial obligation varies by source of commission and depends on whether the officer received financial aid for education from the Army. Officers reach important career decision points—including the Lieutenant Retention Board, the Captain Retention Board and Battery Command—during this time. The experience gained from this process provides valuable career information to officers considering a long-term career (i.e., at least twenty years) in the Army.

Because of the cost of creating the data set for this Phase I research, the scope of the analysis is limited to two decisions. This raises two important specification issues. First, how wide should the decision windows be? Secondly, how much of an officer's career (prior to YOS 11) should the analysis examine? Retention models normally aggregate retention behavior to one-year decision windows corresponding to a particular fiscal year (1 October through 30 September). The methodology employed in this research requires consecutive decision windows of equal length.¹⁷ One-year windows would therefore limit the analysis to the first two years following

¹⁵Officers promoted to Major may remain on active duty until completion of twenty years of service, regardless of whether they are promoted further.

¹⁶It is also possible that some separations in years twelve through twenty are voluntary supply decisions, but most voluntary pre-retirement decisions occur before that point.

¹⁷The main objective of the model is to measure pay responsiveness of retention behavior. One determinant of responsiveness (elasticity) is time. *Ceteris paribus*, elasticities will increase over time, as individuals have more time in which to adjust behavior. Variable window lengths would actually lump different decisions together into the same sort of behavior, and could produce unintended results.

an officer's initial obligation. This clearly excludes many of the early career experiences that influence officers' retention decisions.

The alternative specification selected for this research is two three-year decision windows. This definition is less precise, in that a single set of explanatory variables must predict behavior over a longer time period (i.e., three years). It has the advantage, however, of capturing a large portion of an officer's early career experience. For Military Academy graduates, two three-year windows include the period from the end of their fifth YOS to the end of the eleventh YOS (YOS 6 to YOS 11). The decision windows cover YOS 4 through YOS 9 for most officers commissioned through ROTC and OCS.¹⁸

Dependent Variables. The observed dependent variables were set equal to 1 if an individual remained on active duty for an entire three-year window, and equal to zero if the individual separated at any time during the window. Censored and unobserved second decisions were assigned a value of 0.5 in the equation.

Pay Variables. Specifying three-year decision windows raises the issue of how to measure the explanatory variables, including pay. Because explanatory variables measured for one year are related to three years of retention behavior, they will be less precise indicators than in a model based on annual decisions. One option is to measure each variable by its average over the three years in the window. This, however, would significantly increase the cost of creating the data set for the analysis. Furthermore, it is unclear whether averages would improve the accuracy of estimated effects of factors that influence retention.

The alternative used here is to measure variables with data for the middle year of the three-year window. For example, the first decision window for ROTC and OCS graduates covers YOS 4 through YOS 6. The pay and other explanatory variables are assigned the values corresponding to the fifth year for these officers.¹⁹ This section describes the computation of the ACOL variable, beginning with definitions of military compensation and civilian earnings.

¹⁸See the data section for a discussion of the determination of initial obligation.

¹⁹If an officer left in the first year of the window, the record for the second year would be blank. In that case, the values of variables in the second year were imputed, based on first-year information.

Military compensation includes Basic Pay, Basic Allowance for Subsistence (BAS), Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA). The sum of these elements is defined as Regular Military Compensation (RMC). RMC depends on an officer's YOS, paygrade and dependent status. The definition of YOS adopted here assumes uninterrupted service—an officer's years of service for horizon year i are his/her current YOS + i . Expected pay grade is determined by assigning the average speed of promotion in a branch to each officer in the branch. The housing allowance component of RMC is estimated as a weighted average of housing allowances for officers with and without dependents.²⁰

The expected RMC for year i is defined as

$$RMC_{ijk} = BPAY_{ij} + BAS_j + BAQ_{jk} + VHA_{jk}, \quad (24)$$

where i denotes the horizon-year YOS; j is expected paygrade; and k is expected dependent status. VHA is a national average for the appropriate paygrade-dependents category. No distinction is made between members who received cash allowances and those who received in-kind benefits (i.e., government-supplied housing). Officers in government quarters are assumed to receive benefits equivalent to the foregone allowances.

Military compensation also includes the present value of retirement annuities. The value for any YOS in the member's horizon equals the increase in retirement pay from staying until that horizon year. The value is zero for YOSs less than or equal to 19; the values for YOSs 20 through 30 increase with rising vesting percentages and expected basic pay.

Changes also occurred in the retirement system during the period of analysis. Those officers who entered active duty before September 1980 fall under the original retirement plan. Under this system, the officer vested at the completion of 20 years of creditable service (the end of YOS 20). The retirement annuity associated with a given horizon YOS (20 or higher) is

$$\text{Annuity} = BPAY_{ij} * i * 0.025. \quad (25)$$

²⁰ Officers who already had dependents at the decision point were expected to continue to have dependents. Officers without dependents, however, were assumed to have some positive expectation of acquiring dependents in future years. The model assumes that the probability of an officer remaining without dependents in YOS i equals the proportion of officers in YOS i without dependents to officers in $i - 1$ without dependents.

Thus, an officer retiring after 20 years receives 50% of basic pay, while he/she would get 75% after 30 years. The annuity increases annually to keep pace with the Consumer Price Index.

Officers enlisting after August 1980, but before August 1986, fall under a second retirement system. While their annuity is similar in terms of percentage of pay and vesting point, it is based on an average of their highest three years' basic pay:

$$\text{Annuity} = (\text{High Three})_{ij} * i * 0.025. \quad (26)$$

The final system pertains to officers entering active duty after July 1986.²¹ While the vesting years are also 20 through 30, the percentages vary from 40% to 75%. For this case,

$$\text{Annuity} = (\text{High Three})_{ij} * (i * 0.035 - 0.3). \quad (27)$$

Retirement benefits are also adjusted for inflation. The Cost of Living Adjustment (COLA) under the newest system is one percentage point less than the CPI from retirement until age 62. At 62, the annuity makes a one-time catch-up to recover the inflation losses. After catching up, it reverts to the "CPI - 1" adjustment, but converts the pay percentage to the original calculation ($[\text{High Three}]_{ij} * i * 0.025$).

Retirement pay is expressed in terms of present value. Officers are assumed to receive the annuity from retirement until death at age 72. Since the annuity should (theoretically) stay constant in real dollars, the present value of the stream of payments (at the time of retirement) equals

$$PV(\text{Retirement}) = \text{Annuity} * \frac{1}{r} \left[1 - \frac{1}{(1+r)^t} \right]. \quad (28)$$

Here, r is the personal discount rate and t is the number of years for which the annuity is received.

²¹Very few observations in the data set fall into this group, since the data include observations only through FY90.

The present value of military pay is defined for each horizon year (i) as the discounted sum of the estimates of RMC and retirement annuities from the decision year to year i .²²

$$M_i = \sum_{n=1}^i \left[\frac{RMC_{njk}}{(1+r)^n} + PV(Ret)_i \right]. \quad (29)$$

In this application, pay is expressed in constant FY83 dollars and the discount rate is 10%. Price-level adjustments are based on the annual percentage increase from October to October in the Consumer Price Index for all urban consumers.

The ACOL variable must also include an estimate of the earnings an officer expects in civilian occupations if he/she leaves the Army. Econometric models of post-service earnings are based on the economic theory of human capital. According to this theory, earnings in an occupation are a function of education and experience. Furthermore, earnings increase with experience at a decreasing rate. That is, the relationship between earnings and experience is concave; the log of earnings is usually specified as a quadratic function of experience.

Moreover, job-specific training and experience do not increase expected earnings in alternative jobs; only general human capital does so. Studies of veterans' post-service earnings support this hypothesis.²³ Because at least some of the training that officers receive is military-specific, military experience is expected to yield a lower return than civilian experience. Further, officers who leave the Army change careers; this also contributes to lower expected earnings.

²²Special pays are not included in the definition of military compensation in this research. Special pays are an addition to RMC designed to compensate officers for the negative aspects of specific duty assignments (e.g., danger, time away from families). One might reasonably argue that the value of expected special pays should be included in the calculation of the ACOL variable. It is not possible, however, to accurately determine—given the available data—whether officers are to receive special pays. Moreover, it is inappropriate to include such a pay if the corresponding non-pecuniary job aspect is not included in the retention equation as well.

²³Goldberg and Warner (1987). See also Borjas and Welch (1986).

Variation in civilian earnings captures two effects: differences between individuals and changes over time that affect every worker in the same way. The sources of individual-specific differences include measured factors (e.g., education, experience, occupation and demographic characteristics) and unmeasured factors related to ability.²⁴ Variations over time, on the other hand, are the result of changes in labor-market demand and supply conditions that affect wage rates earned by all workers. Civilian earnings predictions in a time-series, cross-sectional model such as this research require two types of information—an equation that predicts earnings as a function of experience and personal characteristics (e.g., demographic variables and educational level); and an index that tracks changes in real wage levels across the period of analysis.

Models of civilian earnings for military personnel are often estimated using data for individuals with previous military experience.²⁵ These models combine civilian-sector earnings data (either from IRS or Social Security) with personal and service data. The advantage of using veteran's earnings data is that it measures the earnings potential of the sub-population relevant to this research. Accession into the military means that individuals undergo some degree of selection, censoring of tastes for the military and screening of qualities and talents. Further, such data provide the basis for separate estimates of the returns to civilian experience and military experience. These data may introduce bias, however, because they measure the civilian earnings of personnel who elected to leave the military. Members of a cohort who stay do so because they have a stronger preference for military service and/or they face lower earnings prospects in civilian jobs than do officers who leave. Under these circumstances, data for veterans may overestimate the earnings opportunities of officers who stay.

The alternative selected for this study is Current Population Survey (CPS) data that provide a cross-section of the civilian workforce. The Bureau of the Census conducts the CPS for the Bureau of Labor Statistics (BLS). Census contacts about 600,000 households nationwide every month. Interviewers collect information from respondents on labor force and employment status, work experience, income and other data items.

²⁴In many cases, the measured attributes, especially demographic factors, function as proxies for unobservable productivity differences. In other cases, especially education and labor-market experience, the characteristics are productivity signals—the worker has undertaken an investment in acquiring a visible indicator of productivity.

²⁵See Goldberg and Warner (1987), Borjas and Welch (1986), and Smith et. al., (1991).

The CPS Annual Demographic File (March of every year) provides microdata on civilian earnings and demographic information required by a civilian earnings model (including work experience, race, gender and age). It does not, however, include information on military versus civilian experience.

The civilian earnings equation estimated for this study is based on a random sample of 20,000 observations from the March 1979 CPS.²⁶ The civilian earnings equation specifies the natural logarithm of wages as a function of experience, experience squared, race, gender, and educational variables. Table 2 lists the parameter estimates for the equation.

For each officer, expected civilian earnings were estimated based on the sample's mean values for the explanatory variables. Thus, earnings varied only by experience (or YOS). All earnings estimates were then inflated to FY83 dollars and adjusted for the real change in median CPS weekly earnings from 1979 to the appropriate year of analysis.

Table 2
Civilian Earnings Equation

Variable	Estimate	t statistic
Intercept	9.14	861.6
Experience	0.03	32.8
Experience ²	-0.0005	25.6
Female	-0.48	64.4
Non-white	-0.098	11.0
High School	0.19	23.0
Some College	0.31	30.9
Bachelors	0.47	41.1
Bachelors Plus	0.598	47.5
Engineer	0.232	11.3
Social Science	0.103	2.1

²⁶The equation was re-estimated using March 1989 data to verify the results. After adjusting for changes in nominal wage levels, there was no significant difference between the two equations.

Other Explanatory Variables

The retention equation contains other explanatory variables that improve its accuracy. Demographic and service variables may help explain some of the unobserved taste differences among officers and reduce the random error component in the equation. The national annual average unemployment rate is also included as an explanatory variable to measure civilian employment opportunities and uncertainty.

The unemployment rate is expected to have a positive effect on the probability of staying. As the unemployment rate in the civilian sector increases, the probability of finding a job decreases. Thus, the expected value of civilian employment decreases and makes staying in the military relatively more attractive.

The demographic variables in the retention equation included dichotomous variables for race and gender. The race variable (NONWHITE) is defined as zero if the individual was Caucasian and one otherwise. The gender variable (FEMALE) is one if the officer is female and zero if he is male. Marital status at each decision point is also included and defined as one if an officer is married and zero if single.

Two dichotomous variables are also included for Source of Commission (SOC). One variable identifies Military Academy (ACADEMY) graduates, while the other denotes ROTC graduates (ROTC). The coefficients for the included variable estimate retention differences between Academy and OCS graduates, and ROTC and OCS graduates, respectively.²⁷ These differences may reflect the effects of several influences. For example, the initial distribution of "taste" for Army life may differ among officers according to the way in which they entered the Army. These estimates may also measure differences in retention probabilities because of differences in initial obligations by SOC.

DATA

The data used in this analysis were extracted from ARI's Officer Longitudinal Research Data Base (OLRDB). The Manpower and Personnel Research Division (MPRD) developed the OLRDB to conduct research on a wide range of officer issues. The data base tracks individual officers from FY79 to FY90 and contains information extracted from the Officer Master File (OMF), the Separation Officer Master File (SOMF) and the Master and Loss File (MLF) maintained by DMDC.²⁸

²⁷The three SOC categories encompass all members of the sample; there were no Directly Appointed officers.

²⁸Fu Associates, Ltd. (1990), p. 1.

Each record in the OLRDB data base includes career data for an officer during the twelve-year period. Separation and duty flags cover the period from FY70 through FY90. In addition, each record includes a core data set with the most recent values for key variables. While the entire OLRDB is maintained in flat-file (ASCII) format, the CORE data set is also available as a SAS data set.²⁹

Data Issues

Significant issues arose in constructing the data set for this project. The most important issue was the determination of an officer's initial obligation. Unlike the enlisted personnel data bases, the OMF does not include a variable that indicates an officer's Expiration of Term of Service (ETS) date. Officers do not incur explicit reenlistment contracts. Instead, they must complete initial obligations of active-duty service in return for receiving training, education or scholarships. The OMF does, however, contain a data item--the Program Procurement Number (PPN)--that provides some information about initial obligations. The PPN indicates how each officer enters the Army. Each value of the PPN has a length of initial active obligation associated with it. Unfortunately, the PPN is not in the OLRDB and was unavailable for this analysis.

The initial obligation, therefore, had to be estimated with the data available in the OLRDB. The first step in this process was to examine loss rates by YOS, Basic Year Group (BYRGP) and SOC. The end of an officer's initial obligation was defined as the first year of "significant" losses for his/her cohort.³⁰

Other Data Sources

Other data used in this analysis include historical military pay tables from FY79 through FY90, adjusted to real 1983 dollars, and civilian earnings data, referred to previously, from CPS data provided by the Bureau of Labor Statistics (BLS). National average annual unemployment rates and changes in the Consumer Price Index for all urban consumers (CPI-U) also come from BLS.

²⁹Fu Associates, Ltd. (1990), p. 7.

³⁰Under this definition, all included cohorts of Academy graduates had an initial obligation of five years. All OCS graduates were under a four-year initial obligation, as were all but one ROTC year groups. Loss rates for the 1977 BYRGP of ROTC graduates indicated an initial obligation of two years.

Officer Sample Statistics

Table 3 shows sample means for key variables at both the first and second decision points. The data set contains 2,827 individuals, of whom 1,295 also have an observed second decision. Tables 4 through 6 show the mean stay rates and ACOL values by year of analysis for Academy, ROTC and OCS graduates respectively.

Table 3
Estimation Sample Means

Variable	Decision Point 1	Decision Point 2
Stay Rate	0.6102	0.8548
Fiscal Year	84.2416	85.6981
ACOL	15,762.92	20,118.62
Unemployment	7.4291	7.1971
Married	0.6098	0.8000
No. of Deps.	1.0400	1.7969
YOS	5.2925	8.1653
Female	0.2536	0.2749
Non-White	0.0587	0.0448
Academy	0.1779	0.1336
ROTC	0.7022	0.7228

Table 4
Mean Stay Rates and ACOL Values by Year
of Analysis and Decision Point (DP)
Academy Graduates

Year	Mean Stay Rates		Mean ACOL Values (\$)	
	DP 1	DP 2	DP 1	DP 2
1980	0.4091	-----	15,369.61	-----
1981	0.3600	-----	17,520.43	-----
1982	0.4694	-----	17,550.38	-----
1983	0.6500	0.9444	17,229.54	22,021.24
1984	0.6444	0.7778	17,807.81	22,635.44
1985	0.5263	0.8696	18,520.41	23,470.74
1986	0.4677	0.9615	18,036.17	23,211.72
1987	0.6102	0.8966	18,904.91	24,614.04
1988	0.4510	0.8667	19,683.79	24,924.87
1989	0.6522	0.9310	18,976.41	23,537.33

Table 5
Mean Stay Rates and ACOL Values by Year
of Analysis and Decision Point (DP)
ROTC Graduates

Year	Mean Stay Rates		Mean ACOL Values (\$)	
	DP 1	DP 2	DP 1	DP 2
1980	0.7059	-----	12,661.56	-----
1981 ^a	-----	-----	-----	-----
1982	0.6813	-----	15,285.65	-----
1983	0.6489	0.8068	14,940.58	17,958.09
1984 ^a	0.5642	-----	15,168.42	-----
1985	0.6416	0.8755	15,802.68	19,970.68
1986	0.5294	0.8219	15,671.58	19,696.97
1987	0.5753	0.8020	16,526.87	20,436.74
1988	0.4654	0.8288	17,022.48	20,740.52
1989	0.5966	0.8148	16,755.00	20,000.22

^aBlank values result from different initial obligation in 1977 BYRGP.

Table 6
Mean Stay Rates and ACOL Values by Year
of Analysis and Decision Point (DP)
OCS Graduates

Year	Mean Stay Rates		Mean ACOL Values (\$)	
	DP 1	DP 2	DP 1	DP 2
1980	0.6667	----	13,126.75	-----
1981	0.7941	----	15,166.50	-----
1982	0.7391	----	15,272.88	-----
1983	0.7955	1.0000	14,793.45	18,681.14
1984	0.8000	0.9630	15,260.50	19,236.45
1985	0.6875	0.9118	15,655.81	19,894.77
1986	0.5000	0.9143	15,566.22	19,562.07
1987	0.7857	0.9583	16,976.16	20,683.33
1988	0.4615	0.9697	17,042.42	20,948.72
1989	0.6800	0.9412	16,982.36	20,170.50

RESEARCH FINDINGS

Table 7 presents the estimation results for the Air Defense branch. All coefficients are significant at the one percent level.

Table 7
Retention Model Parameter Estimates

Variable	Estimate	t statistic
Intercept	-0.142	-2.516
ACOL	0.000021	4.949
Unemployment	0.034	3.780
Marital Status	0.244	6.052
Female	0.220	5.857
Nonwhite	-0.237	-3.500
Academy	-0.589	-9.474
ROTC	-0.332	6.423
ρ	0.695	24.614
<hr/>		
N ₁	2,827	
N ₂	1,295	
Log Likelihoods		
Full Model		-3,444.93
Restricted Model		-4,110.53
Likelihood Ratio		1,331.21
Goodness of Fit Measures: ^a		
Maddala's pseudo R ²		0.376
McFadden's pseudo R ²		0.162
Cragg & Uhler's pseudo R ²		0.035

^aPseudo-R² measures are necessary in the case of a non-linear estimation technique. Those used here are described in Maddala (1983), pp. 38-40.

The estimates provide strong evidence in support of the ACOL-2 model of officer retention. Relative pay has a significant, positive impact on an officer's propensity to stay. Note that the pay variable is ACOL (which includes current and future compensation as well as retirement pay), not military pay. Likewise, an increase in the unemployment rate leads to an increase in the retention rate of officers. Perhaps most important, however, is that the estimate of the correlation coefficient (ρ) is large and statistically significant. This is strong support of the notion underlying the ACOL-2 model—the second retention decision depends on the outcome at the first decision point because there are individual-specific differences in preferences for Army service among officers.

Pay and Unemployment Effects

The coefficient estimates of the two key economic variables—compensation (ACOL) and unemployment—provide the behavioral basis of the model of officer retention. Two problems, however, make direct interpretation of the estimates difficult: the marginal effects of the explanatory variables on retention probabilities are non-linear, and the model in this research uses a non-standard decision window. The first problem is addressed by solving for the partial derivative of the predicted retention probabilities with respect to the explanatory variables. The partial derivative of the first decision window's stay rate, S_1 , with respect to a continuous variable, X_k , in the probit formulation is:

$$\frac{\partial S_1}{\partial X_k} = \frac{\partial \Phi(X\beta)}{\partial \beta X} \beta_k = \varphi(X\beta) \beta_k. \quad (30)$$

Elasticities are computed to measure the effects of pay and unemployment on retention probabilities. The elasticity is defined as the percentage change in the retention rate with respect to a given percentage change in an explanatory variable. The pay elasticity is defined with respect to military pay. The elasticity in this case is the product of the elasticity of retention with respect to ACOL, and of ACOL with respect to military pay:

$$\epsilon_{S, \text{milpay}} = \epsilon_{S, \text{ACOL}} \cdot \epsilon_{\text{ACOL}, \text{milpay}}. \quad (31)$$

The final issue is the effect of the length of the decision window on responsiveness. While officers may make decisions at any time, a retention model must abstract into discrete time periods. Most previous models use one-year decision windows. Recall that the windows used in this research are three years in length. The equivalent one-year elasticity is approximately equal to one-third of the total three-year elasticity.³¹ Hence, if the elasticities for each of the three years in the first decision window were equal, it would imply a one-year elasticity of about 0.2.

The implied elasticities for pay and the unemployment rate, evaluated at the means of the first and second decisions, are shown in Table 8.

Table 8
Pay and Unemployment Elasticities

Variable	DP 1	DP 2
Pay	0.594	0.342
Unemployment	0.166	0.047

The pay elasticities reported here mean that, other things being equal, a 10% increase in military pay, relative to civilian pay, will result in about a 6% increase in officer retention at the first decision, and a 3.4% increase in retention at the second decision. These levels are roughly

³¹To see this, define:

$$S_1 = r_{11} \cdot r_{12} \cdot r_{13}.$$

S_1 is the stay rate over the first decision window. Hence, r_{11} is the one year retention rate in the first year of the window, r_{12} is the one year retention rate in the second year, and so forth. Then,

$$\ln(S_1) = \ln(r_{11}) + \ln(r_{12}) + \ln(r_{13}). \text{ and}$$

$$\partial(\ln S_1) / \partial(\ln \text{MILPAY}) = \epsilon_{S_1, \text{MILPAY}} = \epsilon_{r_{11}, \text{MILPAY}} + \epsilon_{r_{12}, \text{MILPAY}} + \epsilon_{r_{13}, \text{MILPAY}}.$$

equivalent to a 2% increase in the one-year retention rate, as discussed above. Similarly, a 10% increase in the civilian unemployment rate results in a 1.7% increase in the probability of staying at the first decision, and about a 0.5% increase at the second decision. Alternatively, an increase in the civilian unemployment rate by one percentage point, from 7.4% to 8.4%, leads to a 1.2 percentage point increase in the retention rate at the first decision point.

The research findings indicate that the retention decisions of Army officers in the ADA community are responsive to changes in pay and unemployment. The magnitude of the response is less than that typically found for enlisted personnel, but of roughly the same order of magnitude as has been found for non-pilot officers in other Services.³²

The bivariate probit specification explicitly accounts for changes in the underlying distribution of unobservable factors (tastes) affecting retention at the second decision when the first-decision retention rate changes. This is demonstrated by considering a cross-period pay elasticity—the percentage change in retention probability at the second decision with respect to changes in military pay at the first decision. This elasticity is estimated by simulating a 10% military pay increase, affecting only officers at the first decision. The results of this simulation are shown in Table 9.

Table 9
Cross-Decision Point Pay Elasticity

	Decision 1	Decision 2
Base rates	0.602	0.823
10% Pay Raise (First decision point only)	0.638	0.809
Elasticity	0.598	-0.170

³²Smith, et. al. (1991) found first-term (one-year) pay elasticities of between 1 and 2 for three Army occupational specialties. Hogan and Goon (1989) found a pay elasticity of about 0.35 for non-rated Air Force officers in the first year after completing their initial service obligation.

A 10% increase in pay at the first decision leads to a 6% increase in the retention rate at that point and in a 1.7% decline in retention at the second decision for that cohort. The pay increase at the first decision induces officers to stay who otherwise would have left. When these officers reach the second decision, they leave the Army because the pay increase is not maintained at the second decision. This reduces the overall retention rate at the second decision point.

Demographic Effects

Table 7 provides estimates of the magnitude of the effects of factors correlated with "taste" for Army life, including marital status, race, gender and SOC. The estimates measure the difference between a typical officer possessing that attribute and an otherwise similar officer who does not. For example, the estimated effect of marital status shows the difference in retention probabilities between a single, Caucasian, male, ROTC officer and a married, Caucasian, male, ROTC officer. The findings concerning taste effects are as follows:

- The retention rate of a single officer is 0.096 percentage points lower at the first window, and 0.044 percentage points lower at the second than a married officer.
- A female officer has a retention rate that is 0.082 percentage points higher at the first retention point, and 0.035 percentage points higher at the second than her male counterpart.
- The probability that a non-Caucasian officer will elect to stay in the Army is 0.093 percentage points lower at the first retention point and 0.042 percentage points lower at the second point than an otherwise similar Caucasian officer.
- The retention rate of Academy graduates is 0.101 percentage points lower at the first decision point and 0.046 percentage points lower at the second decision window than ROTC graduates.
- An OCS graduate has a retention rate that is 0.121 percentage points higher at the first decision point and 0.052 percentage points higher at the second than ROTC graduates.

Alternative Specifications

Alternative versions of the officer ACOL-2 model reported above have been estimated in order to examine the effect of changes in the specification of the model on predicted behavior. In particular, the sensitivity analysis focuses on the effects of: (a) controlling for unobserved heterogeneity, and (b) alternative definitions of the decision windows.

The ACOL-2 model accounts for self selection among officers by estimating the correlation in unobserved taste components between the first and second retention decisions (i.e., ρ). According to this specification, officers who reach the second decision have, on average, a stronger preference for service than officers making their first decisions. Failure to control for the unobserved taste effects may bias estimates of pay effects upward—if one erroneously assumed no correlation in unobserved tastes, the reported coefficient of the ACOL variable would overstate the impact of pay on the probability of staying.

The original specification has been re-estimated with the correlation coefficient (ρ) constrained to equal zero, in order to examine the issue of upward bias. In the absence of a correlation coefficient, the model reduces to a simple, pooled probit model including both first and second retention decisions. The estimate of the ACOL coefficient for this specification did indeed increase (by about 14%). This finding provides additional confirmation of the validity of the ACOL-2 model of officer retention.

Another important specification issue concerns the definition of a decision window underlying the estimates in Table 7. Decision points are defined in this research as three-year windows because of the restriction to two decision points in the bivariate model and the desire to capture a fairly large portion of the officer's career prior to selection to Major.

Decision windows are usually defined as one year intervals in military manpower research. For example, one-year intervals for retention decisions were used by Hogan and Goon (1989) in the analysis of Air Force officer retention. Two one-year decision points were specified by Smith, et. al. (1991) in their bivariate probit formulation of enlisted retention decisions.

The ACOL-2 model has been estimated assuming one-year windows to evaluate the sensitivity of estimates to the length of decision windows. In addition to differences in responsiveness correlated with time (discussed previously), the issue of proper identification of an officer's initial obligation becomes more critical as the window size shrinks.

Misidentification of an officer's initial obligation may introduce significant error into the estimates of pay and other effects. For instance, if an officer's initial obligation actually ends after the first decision window and he/she leaves the Army (during what has been defined as the "second" decision), a voluntary stay decision is recorded at the first decision point and is related to the value of the ACOL variable at that point. The model then treats the officer's behavior as a voluntary separation at the second decision. Because the value of the ACOL variable rises with tenure, the separation decision is related to a higher ACOL value than is the stay decision at the first point. Thus, incorrectly identifying the initial obligations could result in lower ACOL values associated with retention as compared to separation. This could cause the coefficients on the ACOL variable to exhibit a negative effect of pay on retention when the true relationship is positive.

Defining window widths as three years may reduce the probability that officers were obligated to stay in the Army throughout the decision window. Even if the officer were still under obligation in the first year of the first decision window, that window would include two years of observed voluntary behavior. In a one-year window specification, however, the same error would cause the entire first window to erroneously identify obligated service as voluntary service.

Initially, two one-year decision points were defined to be the first and second year of the first three-year decision window. The model in Table 7 was then estimated for this case. The sign of the ACOL variable became negative and the effects of the other variables shrank toward zero. The reason for this outcome may be that a significant number of officers were still under their initial obligations during the first year and were free to leave in the second year (and did so). This case would result in the specification errors discussed above. Low ACOL values would be incorrectly related to voluntary decisions to stay, while higher ACOL values would be associated with separations.

Consequently, the model was re-estimated with the decision windows moved to the second and third years of the first three-year decision window. The resulting pay and unemployment elasticities, shown in Table 10, are consistent with the possibility that officers were assumed to have ended their obligation before they actually had.³³

³³It is interesting to note that Hogan and Goon (1989) found a pay elasticity of 0.35 for non-rated Air Force officers in the first year after their obligation.

Table 10

Pay and Unemployment Elasticities
One-Year Decision Windows

Variable	DP 1	DP 2
Pay	0.351	0.233
Unemployment	0.173	0.058

CONCLUSIONS

The research findings for the Air Defense Artillery (ADA) branch indicate that unobserved factors related to preference for service play an important role in determining which officers stay in the Army. The findings show that officers also respond to financial incentives in deciding whether to stay in or leave the Army during the first six years after their initial obligations are complete. Moreover, female ADA officers, married officers, and Caucasian officers tend to stay at significantly higher rates than others. Officers who entered through West Point or ROTC tend to stay at somewhat lower rates than others.

The primary data base used in this analysis is the Officer Longitudinal Research Data Base (OLRDB), a linked, longitudinal data base prepared for research and analysis by the Army Research Institute. The OLRDB is a rich source of information on officer retention behavior, and of the demographic and institutional characteristics of the officer community. The only problem of importance in the data base is an inability to determine each officer's period of initial obligation. A less precise method of estimating initial obligation based on Source of Commission is used in the analysis.

There are several important policy implications of this research. Army officers in the ADA community respond to economic incentives, as measured by relative pay and the civilian unemployment rate. A drawdown during a recession will be somewhat more difficult, as the results suggest, because officers are more reluctant to leave during periods of high unemployment rates. In fact, a 7% civilian unemployment

rate, rather than a 5% rate, results in retention rates at the first decision that are approximately 7% higher.

Military pay, compared to civilian pay opportunities, also has a significant effect on officer retention. If pay were to decline by 10%, one would expect to observe roughly a 6% decline in retention at the first decision point, and a 3.4% decline at the second decision.

Implications for Further Analysis

This analysis can be extended in several dimensions. First, a general panel probit method, using the Butler-Moffitt quadrature technique to avoid the evaluation of multiple integrals, permits estimation of multiple one-year decision windows.³⁴ This econometric model provides insights into retention behavior at multiple decision points, and can be more easily incorporated into an inventory model. Second, the methods developed here can readily be expanded to other Army communities. Similarities and differences across occupational fields in underlying retention behavior and responsiveness to economic incentives would provide useful insights about the effects of the current drawdown on the structure of the officer force.

ARI recognizes the need for a model that integrates multiple changes in personnel policies and estimates their impact on manpower costs and force structure. While Congress may mandate a large drawdown, it is incumbent on Army leadership to assess the risk associated with personnel reductions and ensure that risk-minimizing, least-cost options are considered and evaluated.

This study focused on developing, specifying and estimating a model of officer retention behavior for one occupational specialty (the ADA branch). Further work must integrate these results and Army Manpower Cost System (AMCOS) data into a prototype officer inventory projection and cost model.

As this research is applied to the Army officer community as a whole, personnel-policy decision makers will be able to address a wide range of issues:

- Design and analysis of compensation initiatives, e.g.,

³⁴Butler and Moffitt (1982).

- What is the budget cost of a careerist bonus sufficient to retain an additional 100 officers?
- Cost-benefit analysis of alternative force structures, e.g.,
 - How are force cost reductions achievable with minimum readiness sacrifice?
- Force manning implications of alternative personnel policies, e.g.,
 - How will a one-year promotion moratorium feed back into reduced career force flow?
- Quantitative and statistically significant assessment of personnel effects and manpower costs of policy to support Army staff response to OSD/OMB or Congressional budget cuts, e.g.,
 - How will severe reductions in promotion opportunities affect out-year force structures? Will there be a sufficient number of qualified O-4s to meet reduced force requirements?

The policy analysis model will incorporate the behavioral results of this research (and their secondary and tertiary effects on out-year inventories) into a reliable, consistent tool for decision makers.

ARI developed a variation on the ACOL model in a model of enlisted retention intentions. Hogan (1990) used a household model of reenlistment behavior to measure the role of family or household factors in the decision process. This study used estimates of changes in the spouse's labor market rent to enhance the model's aggregate estimate of economic effects. Research findings indicated that the reenlistment rate elasticity with respect to changes in spouse rents was about -0.12. The Family ACOL framework explains more fully the costs and benefits associated with the retention decision for married Army personnel and reduces bias in estimates of the effects of traditional retention-equation explanatory variables. The chief drawback of this approach is that such models have relied on survey data for which the dependent variable is stated intention to reenlist rather than observed behavior. Future research may be able to merge survey data with personnel records to integrate the best features of each model.

A final recommendation concerns the availability of personnel research data. The location of the OLRDB and other data on a mainframe computer greatly increases research costs and often causes expensive research delays. Current technol-

ogy makes locating these data sets on a dedicated personal computer at ARI not only feasible, but cost-efficient as well. The dedicated file server could make use of database management system, compression and decompression routines and state-of-the-art hardware to provide the speed and storage of a mainframe computer in the convenience of a local PC environment.

REFERENCES

- Arguden, R. Yilmaz (1986). Personnel management in the military: Effects of retirement policies on the retention of personnel (R-3342-AF). Santa Monica, CA: RAND Corporation.
- Black, Matthew, Hogan, Paul F., & Sylwester, Stephen (1987). Dynamic model of Navy reenlistment behavior. Arlington, VA: SRA Corporation.
- Black, Matthew, Moffitt, Robert, & Warner, John T. (1990). The dynamics of job separation: The case of Federal employees. Journal of Applied Econometrics, 5, 245-262.
- Borjas, George J., & Welch, Finis (1986). The postservice earnings of military retirees. In Curtis Gilroy (Ed.), Army manpower economics. Boulder, CO: Westview Press.
- Butler, John S., & Moffitt, Robert (1982). A computationally efficient quadrature procedure for the one-factor multinomial probit model. Econometrica, 50, 761-764.
- Enns, John H., Nelson, Gary, & Warner, John T. (1984). Retention and retirement: The case of the U.S. military. Policy Sciences, 17, 101-121.
- Fu Associates, Ltd. (1990). Summary report of the Officer Longitudinal Research Data Base update. Arlington, VA: Fu Associates, Ltd.
- Goldberg, Matthew S., & Warner, John T. (1987). Military experience, civilian experience and the earnings of veterans. Journal of Human Resources, 22, 62-81.
- Gotz, Glenn A., & McCall, John J. (1983). Sequential analysis of the stay/leave decision: U.S. Air Force officers. Management Science, 29, 335-351.
- Greene, William H. (1990). Econometric analysis. New York: Macmillan Publishing Company.

- Hogan, Paul F., (1990). Family annualized cost of leaving: The household as the decision unit in military retention (ARI Technical Report 890). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (AD A224 394)
- Hogan, Paul F., & Goon, Marjorie (1989). An econometric analysis of Air Force officer retention: Re-estimation of the DOPMS model. Arlington, VA: SRA Corporation.
- Maddala, G.S. (1983). Limited-dependent and qualitative variables in econometrics. Cambridge: Cambridge University Press.
- Smith, D. Alton, Sylwester, Stephen D., & Villa, Christine M. (1991). Army reenlistment models. In Curtis Gilroy, David K. Horne, & D. Alton Smith (Eds.), Military compensation and personnel retention: Models and evidence. Alexandria, VA: U.S. Army Research Institute, 43-179.
- Warner, John T., & Goldberg, Matthew S. (1984). The influence of non-pecuniary factors on labor supply: The case of Navy enlisted personnel. Review of Economics and Statistics, 66, 26-35.