NBER WORKING PAPER SERIES

THE MILITARY PENSION, COMPENSATION, AND RETIREMENT OF U.S. AIR FORCE PILOTS

John A. Ausink
David A. Wise

Working Paper No. 4593

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December, 1993

This paper is based on Ausink's Ph.D dissertation: *The Effect of Changes in Compensation on a Pilot's Decision to Leave the Air Force,* Harvard University, May 1991. Funding was provided by the National Institute on Aging. Any opinions expressed herein are those of the authors and not those of the United States Air Force, Harvard University, or the National Bureau of Economic Research. This paper is part of NBER's research programs in Aging and Labor Studies.

NBER Working Paper #4593
December 1993

THE MILITARY PENSION, COMPENSATION, AND RETIREMENT OF U.S. AIR FORCE PILOTS

ABSTRACT

This paper uses the option value model of Stock and Wise to analyze the departure patterns of a sample of pilots in the United States Air Force. Pilot compensation and the military pension are described, as are some details of the option value model and two other models: the Annualized Cost of Leaving (ACOL) model, which is used by the Department of Defense, and a variant of a dynamic programming model proposed by Daula and Moffitt. The option value model captures departure behavior much better than the ACOL model, and substantially better than the dynamic programming model. The superiority of the option value model to the dynamic programming formulation raises the possibility that individual decision-making may not always be best modeled by a formulation that is intended to capture "correct" economic financial calculations. This is consistent with findings by Lumsdaine, Stock and Wise for civilians in a Fortune 500 firm.

John A. Ausink
Department of the Air Force
HQ USAFA/DFMS
2354 Fairchild Drive, Suite 6D2A
USAF Academy, Co 80840-6252

David A. Wise
National Bureau of Economic Research
1050 Massachusetts Avenue
Cambridge, MA 02138-5398
and NBER

Econometric models of job exit are of interest for at least two reasons. There has been a significant decline in the civilian labor force participation of older Americans for the past twenty years [21]. During the same period, private pension coverage has increased markedly, and social security benefits have risen. The study of relationships between the two trends is of interest to economists attempting to explain the incentives that pension plans may provide in encouraging workers to change jobs or stop working, and is also important to firms who may want to affect employee retirement behavior by changing the provisions of their pension plans.

In the military, there is a slightly different perspective. The armed forces must maintain adequate numbers of trained and experienced personnel without the realistic possibility of lateral job entry to replace losses. A shortage of experienced military pilots cannot be eliminated by hiring pilots from another military, for example. The absence of this remedy for the loss of personnel means that shortfalls in any cohort are difficult to correct, and the potential incentive effects of changes in compensation must be considered before they are made.

Both the civilian trend and military problem are sufficient to have encouraged extensive research. The military, through research at the Rand Corporation, the Center for Naval Analyses, and the Pentagon has been refining models of military retirement since 1975. Indeed, Baldwin [3] states that the economics of military manpower emerged as a branch of defense economics with the end of the draft.

In this paper, we use the option value model of retirement behavior developed by Stock and Wise [19] to examine the effects of compensation on the decision of Air Force pilots to leave the military. Section I provides background information. We start with a brief discussion of the problem of pilot retention in the Air Force and the compensation changes that have been suggested to solve it. Because a large part of career military compensation is in the form of pension benefits, we discuss the value of these benefits. In Section II, after a description of the data used in this study, we describe the option value model and highlight how it differs from other models that have been used to study this topic. Section III presents graphical displays of the predictive accuracy of the option value model and compares these to the accuracy of competing models. Of particular interest is that the option value model, which can be viewed as a simplified dynamic programming specification, predicts complicated military retirement patterns much better than the dynamic programming formulation to which it is compared. The effects on the distribution of the pilot population (by years of service) of selected changes in compensation are discussed in Section III.B.

I. BACKGROUND

A. Pilot Compensation

Military pilots have received extra pay ever since the Army Appropriation Act of March 2, 1913, which provided an increase of 35% in pay and allowances for Army officers flying heavier-than-air craft. According to Bartholomew ([5], p. 93) the pay was strictly to compensate pilots for the extremely hazardous duty they were undertaking. The Career Compensation Act of 1949 initiated a change in philosophy for the special pay, saying

"...the incentive to engage and remain in hazardous occupations provided a more realistic and practical basis for determining the rates of special pay than the theory of recompense for shorter career expectancy. The recompense or replacement concept,

although promoted for many years as the sole argument for hazard pay, was found wanting for several reasons"
([5], p. 94)

In other words, instead of trying to make their shorter lives happier because of higher pay, the government should pay pilots enough to make them prefer employment in the military to employment in civilian positions. The incentive pay structure adopted by the Career Compensation Act provided extra pay that depended only on the rank of the member who was flying.

By 1955, the services were having difficulty recruiting pilots and retaining younger pilots who had completed their service obligation, and the incentive pay system was changed so that flight pay depended not only on grade, but on years of service.

Another change in philosophy occurred in 1974, when Congress decided that flight pay should be more than compensation for actual flying duties. Instead, because of the large investment made by the military in the training of its pilots, it was felt that extra pay should be structured so that a pilot has the incentive to remain in the service for a full career. The Aviation Career Incentive Pay (ACIP) Act was an effort to do this.

As the 1980's drew to a close, it became apparent that ACIP was no longer sufficient to retain enough pilots to meet projected defense needs. According to the January 17, 1989 Report of the Secretary of Defense, the armed forces were losing one experienced fighter pilot per day in 1988, and this represented a cost of more than $2.5 million dollars to the government ([12], p.103). The DoD Annual Report for 1989 echoes the concern that high pilot losses jeopardized combat readiness of the armed forces ([13], p. 125). Assuming the low 1989 retention rates continued from 1991 to 1994, the Air Force predicted that "shortfalls" of pilots in the 1 to 14 years of service groups would rise from 895 in Fiscal Year 1989 to over 2100 in 1994 ([11], p. 6-24).

The major reason for the loss of pilots is increased hiring by commercial airlines. A surge of pilot hiring in the 1960s, which translated into a large retirement rate of commercial pilots in the 90s, has led to another surge of hiring. According to the Department of Defense, 37% of the commercial jet pilot force (approximately 43,000) will need to be replaced in the 1990s ([11], p.2-5). Despite turmoil in the airline industry because of the Persian Gulf crisis in 1990, many major airlines continued the aggressive hiring practices that contributed to the fact that, for the third year in a row, Air Force pilot losses exceeded production by more than 800.

The desire of military pilots to leave the service to fly for commercial airlines is understandable when potential earnings are considered. For example, a married Air Force pilot with eight years of service in 1989 would be earning slightly more than $45,000 annually, and could look forward to making over $61,000 per year (using 1989 pay tables) by the time he or she reached 20 years of service. If this same captain left the Air Force after 8 years of service and landed a job with a major airline, annual salary could be well over $100,000 after ten years. [these figures are based on table 2-4 of [11]].

According to the Department of Defense Aviator Retention Study,

> "When faced with the choice between an 'average' private sector job and a military flying career, the military career competes favorably with its challenging jobs, security, job satisfaction, and opportunities for travel, advanced education, and service to country. The evidence is overwhelming, however, that lucrative airline pilot careers, when readily available, are preferred and account for the majority of military pilot separations." ([11], p. 2-8)

With continuing Navy pilot shortages, and increasing losses of Air Force pilots, Congress authorized a new bonus program in 1988 called Aviator Continuation Pay (ACP).

In the Air Force, this program provides bonuses that depend on the years of service of the pilot, and require that the pilot agree to serve for a total of 14 years in order to receive the money. For example, a pilot with 6 years of service can receive an annual bonus of 12,000 by agreeing to remain in the service until completing 14 years of service; the bonus will not be received without incurring the obligation. The size of the bonus decreases with seniority, until a pilot who has completed 12 years of service will be offered $6,500 per year to remain through 14 years of service [6]. In 1989, the cost of this program from Fiscal Year 1990 through Fiscal Year 1994 was anticipated to be approximately $94 million.

While the added compensation from ACP and ACIP is substantial, the advantage of remaining in the military long enough to earn retirement benefits (benefits that are available to pilots and non-pilots alike) must also be considered. Compared to most civilian pension plans, the military pension is simple to calculate and extremely generous, though it does have the disadvantage, from the military member's point of view, of having cliff vesting (with a vengeance): pension benefits are not available until a person serves for 20 years; anyone who leaves the military before twenty years of service receives no pension benefits.

B. The Military Pension

The structure of the military pension system has remained relatively unchanged since 1916, when an act of Congress (Public Law No. 64-241, 39 Stat. 579) established the formula that retired pay would equal 2.5% of monthly pay per year of service up to a maximum of 75% at 30 years of service ([5], p.235) Most changes since then have dealt with the nature of cost of living adjustments (COLAs) that are part of the pension, what type of pay is used for the calculation of the benefit, and when retirement is authorized. Probably the most complicated aspect of the pension now is the fact that, depending on when they entered the service, individuals may be covered by one of three different plans. The tabulation below describes the differences among them, and which military members are affected by them. The information is from Air Force Regulation 35-7, Chapter 7.

CHARACTERISTICS OF CURRENT RETIREMENT STATUS

Date of Entry	Calculation of Benefit	Cost of Living Adjustment
Before 8 Sep 1980	After 20 years of service, 50% of final basic pay. Benefit increases 2.5% for each additional year served, up to 75%.	Annual COLA to match inflation
Between 8 Sep 1890 and 1 Aug 1986	After 20 years of service, 50% of the average basic pay of the highest three earnings years. Benefit increases 2.5% for each additional year served, up to 75%.	Annual COLA to match inflation
After 1 Aug 1986	After 20 years of service, 40% of the average basic bay of the highest three earnings years. Benefit increases 3.5% for each additional year served up to 75%.	Annual COLA 1% below Consumer Price Index (CPI) until age 62. At age 62, pension is recalculated to be what it would have been if entry was before 8 Sep 1980. After age 62, annual COLA is again 1% below CPI.

Using 1988 pay tables, a typical Lt Col retiring after 20 years of service would have a monthly pension of approximately $22,152 under the first plan, $21,000 under the second, and $17,000 under the third. The DoD estimates that the present values of the pension benefits at the time of retirement would be $595,000; $553,000, and $445,000 respectively.

II. THE DATA AND MODELS

A. The Sample

The Air Force maintains the Longitudinal Cohort File, a file of information on Air Force personnel that is updated in October every year and includes data from 1974 to 1991. From this file, the Air Force Military Personnel Center (MPC) produced a random sample of 5000 male pilots who in 1987 had completed between six and 27 years of commissioned service. Individuals who had served as enlisted personnel before being commissioned as officers were excluded from the sample, because historically, departure patterns for those with prior service have been different from those of officers without prior service.

Officers in the file are recorded as being present or not present in the Air Force when the file is updated annually. We have no record of actual employment after leaving the Air Force, but we assume that departures are voluntary and that the decision to leave is made based on a comparison of future compensation from the military to potential compensation from a civilian airline position. The file lists the Air Force Command to which the pilot belongs, and the model parameter estimates in this paper are based on the 1803 officers who were in the Strategic Air Command (SAC) or Military Airlift Command (MAC). Pilots in these two commands had fairly similar departure rates from 1987 - 1989, and the "heavy" aircraft flown in these commands require skills similar to those needed in civilian airline positions. For the purposes of calculating income, the first full year of civilian pay or pension receipt was considered to be the year after an individual was recorded as not present. For example, a pilot present in 1987 but absent in 1988 receives his first full year of civilian pay (and pension benefits, if entitled to them) in 1989.

B. The Option Value Model

Following Stock and Wise [19]: In any given year s, an Air Force pilot may expect to earn Y_s dollars in the Air Force and, if he or she leaves the military, a salary C_s in a new civilian job plus any retirement benefits B_s that have been earned as a result of military service. If we say that the individual indirectly derives utility $U_M(s)$ from military income in year s and utility $U_C(s)$ from civilian employment plus military pension benefits, we can develop an expression for the utility of working until different times in the future. Suppose that no one lives beyond year T, that individuals discount future earnings by a factor β, and that r is the first year in which civilian earnings and/or retirement benefits are received. For an individual in year t considering being out of the Air Force in year r, the value of that decision is

$$V_t(r)=\sum_{s=t}^{r-1}\beta^{s-t}U_M(s)+\sum_{s=r}^{T}\beta^{s-t}U_C(s) \qquad (1)$$

that is, the discounted sum of the utility of working in the Air Force from now until year r-1 plus the discounted sum of the utility of working elsewhere and receiving pension benefits (if any) from year r until death.

Similarly, the value of leaving the Air Force now, in year t, is

$$V_t(t)=\sum_{s=t}^{T}\beta^{s-t}U_C(s)\,. \qquad (2)$$

The expected gain in utility from delaying departure until year r is given by

$$G_t(r) = E_t V_t(r) - E_t V_t(t) \,. \tag{3}$$

It will be to the person's advantage to delay the decision to leave the military until year r if the expected gain in utility is greater than zero. We will assume that an individual will leave the Air Force if, when considering all future departure dates, the maximum gain possible is less than or equal to zero, that is, if $G_t(r^*) <= 0$, where r* is the potential departure year with the maximum gain.

Assume that an individual's utility has a constant relative risk aversion form:

$$\begin{aligned} U_M(s) &= Y_s^{\gamma} + \omega_s \\ U_C(s) &= (C_s(r) + kB_s(r))^{\gamma} + \xi_s \end{aligned} \tag{4}$$

The potential civilian income, $C_s(r)$, may, and the retirement benefits, $B_s(r)$, will, depend on the year r that the individual is first in a civilian position, and so they are shown as functions of the departure year. Additionally, the coefficient k is introduced to account for the possibility that a person may value military pension earnings differently than earnings that require labor. The error terms are meant to capture unobserved determinants of departure. For example, they could reflect individual preferences for work versus leisure. They could also account for differing tastes for military life, variable tax filing status that will change the effect of non-taxable portions of military income, differing assessments of potential for military advancement, and variable unobserved wealth. For a given individual in the military, there should be considerable persistence in these random effects over time, and so the error terms are assumed to follow a first order Markov process:

$$\omega_s = \rho\omega_{s-1} + \epsilon_{\omega s} \qquad E_{s-1}(\epsilon_{\omega s}) = 0\,,$$

$$\xi_s = \rho\xi_{s-1} + \epsilon_{\xi s} \qquad E_{s-1}(\epsilon_{\xi s}) = 0\,. \tag{5}$$

At time t, the individual knows both ω and ξ, but not the values that evolve over time. With these specifications, the expected gain from postponing departure until year r can be written

$$\begin{aligned} G_t(r) &= \sum_{s=t}^{r-1} \beta^{s-t} E_t(Y_s^\gamma + \omega_s) + \sum_{s=r}^{T} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma + \xi_s] - \sum_{s=t}^{T} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma + \xi_s] \\ &= \sum_{s=t}^{r-1} \beta^{s-t} E_t(Y_s^\gamma) - \sum_{s=t}^{r-1} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma] + \sum_{s=t}^{r-1} \beta^{s-t} E_t(\omega_s - \xi_s) \\ &= g_t(r) + \phi_t(r)\,. \end{aligned} \tag{6}$$

The function ϕ contains the random effects, and the function g contains the rest. We must also take into account the likelihood that an individual will survive to receive the earnings anticipated. If we let $\pi(s|t)$ represent the probability that a person will be alive in year s given he is alive in year t, and assume this probability is independent of the individual error effects, the functions $g_t(r)$ and $\phi_t(r)$ become

$$g_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} \pi(s|t) E_t(Y_s^\gamma) + \sum_{s=r}^{r-1} \beta^{s-t} \pi(s|t) E_t[(C_s(r) + kB_s(r))^\gamma]$$

and (7)

$$\varphi_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} \pi(s|t) E_t(\omega_s - \xi_s)\,.$$

Under the Markov assumption for the individual specific errors, the expectation at time t can be written $E_t(\omega_s) = \rho^{s-t}\omega_t$ and $E_t(\xi_s) = \rho^{s-t}\xi_t$ and so the function ϕ takes the form

$$\varphi_t(r) = \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\rho^{s-t}(\omega_t - \xi_t) = K_t(r)\nu_t$$

where (8)

$$K_t(r) = \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\rho^{s-t} \quad \text{and} \quad \nu_t = \omega_t - \xi_t .$$

The term $K_t(r)$ cumulates the deflators that yield the present value in year t of the future expected values of the random components of utility. The further r is in the future, the larger is $K_t(r)$. That is, the more distant the potential retirement age, the greater the uncertainty about it, yielding a heteroskedastic disturbance term. Finally, then, the expected gain in year t from postponing departure from the Air Force until year r is

$$G_t(r) = g_t(r) + K_t(r)\nu_t \quad . \tag{9}$$

If we let R be a random variable representing the year of departure, the probability that an individual will be gone in year t is given by

$$\begin{aligned} Pr[R=t] &= Pr[G_t(r) \le 0] \\ &= Pr[g_t(r) + K_t(r)\nu_t \le 0] \\ &= Pr\left[\frac{g_t(r)}{K_t(r)}\right] \le -\nu_t \qquad \forall\ r \epsilon [t+1,\ldots,T] \\ &= Pr\left[\frac{g_t(r*)}{K_t(r*)}\right] \le -\nu_t \end{aligned} \tag{10}$$

where r* is the future year that gives the largest value for the gain from remaining in the Air Force.[2]

C. Other Models

An alternative model has been used by the Military for some time to study retirement behavior and we compare the predictive validity of that model with the option value model discussed above. It is also of interest to consider how the option value model compares with a more complex stochastic dynamic programming model. Lumsdaine, Stock, and Wise [17] have done this for civilian employees. The cumulating evidence from their work suggests that the more economically accurate stochastic dynamic programming model does no better than the simpler option value model at approximating the actual decisions of employees. The military pension structure offers a particularly good test to the predictive validity of these models and we present such comparisons in this paper. We describe a popular Department of Defense model and a dynamic programming model.

1. The ACOL Model

The Annualized Cost of Leaving (ACOL) model was developed by John T. Warner in [20] and was the analytical basis for the Fifth Quadrennial Review of Military Compensation's study of changes in the military pension system. It is used frequently enough by the Air Force Personnel Analysis Center to have been incorporated in an interactive

---

[2]The analysis presented in this paper is based on retirement decisions in a single year. Stock and Wise [19] describe an extension of the model to accommodate repeated observation for the same person over time. Estimates based on more than one consecutive year are presented in Ausink [2] and the results are virtually the same as those presented here.

computer program called the "Compensation Model" for determining the effects of various changes in compensation policies [18]. The Department of Defense Aviator Retention Study [11] and the Congressional Budget Office [7] also relied on the model, either directly or indirectly, to predict the effects of the 1989 pilot bonus program.

The description here is intended to bring out the relationship between the ACOL and the option value models. Assume that individuals are risk neutral ($\gamma = 1$) that military compensation and pension benefits are valued the same (the k in the option value model is 1), and that individuals have unobserved random taste Γ for military employment. In year s, the utilities associated with Air Force work and with civilian employment are then

$$U_M(s)=Y_s+\Gamma \quad \text{and} \quad U_C(s)=C_s(r)+B_s(r)\,. \tag{11}$$

In year t, the expected value of beginning civilian employment in year r is

$$V_t(r)=\sum_{s=t}^{r-1}\beta^{s-t}\pi(s\,|\,t)(Y_s+\Gamma) + \sum_{s=r}^{T}\beta^{s-t}\pi(s\,|\,t)(C_s(r)+B_s(r)) \tag{12}$$

and the value of leaving the Air Force for a new job now is

$$V_t(t)=\sum_{s=t}^{T}\beta^{s-t}\pi(s\,|\,t)(C_s(r)+B_s(r)) \tag{13}$$

In year t, the cost of leaving instead of remaining until year r, $COL_t(r)$, is the benefit foregone by making the decision to leave in year t,

$$\begin{aligned} COL_t(r) &= V_t(r)-V_t(t) \\ &= \sum_{s=t}^{r-1}\beta^{s-t}\pi(s\,|\,t)Y_s + \sum_{s=t}^{r-1}\beta^{s-t}\pi(s\,|\,t)(C_s(r)+B_s(r)) + \Gamma\sum_{s=t}^{r-1}\beta^{s-t}\pi(s\,|\,t) \end{aligned} \tag{14}$$

This description has the same form as equation (9), $G_t(r) = g_t(r) + K_t(r)v_t$, in the option value model, with the random taste term replacing the Markov error structure.

A person retires if the maximum of

$$ACOL_t(r) = \left[\sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\right]^{-1} \left[\sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)Y_s + \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)(C_s(r)+B_s(r))\right] + \Gamma. \quad (15)$$

is less than zero.[3] Or, if $ACOL_t(r^*) = g_t(r^*)/K_t(r^*) + \Gamma < 0$, using the option value definitions (equation 10).

In practice, the model is estimated using the logit formulation

$$y = \alpha_0 + \alpha_1 \, ACOL^* + \epsilon \quad (16)$$

with ACOL* calculated based on an assumed discount rate.[4]

2. A Stochastic Dynamic Programming Specification

We use the stochastic dynamic programming specification used by Lumsdaine, Stock, and Wise [17], which is a variant to the model proposed by Daula and Moffitt [8] to study army enlisted behavior, which is in turn a variant of the Gotz and McCall [14] dynamic programming model of retention behavior for Air Force officers. When estimating retirement in one period, the Gotz-McCall model is the same as the model of Daula and Moffitt.

[3] This term is also equal to the annualized cost of leaving, which gives rise to the model name.

[4] This is similar to a probit specification used in Lumsdaine, Stock and Wise in [17], comparing the predictive validity of more and less complex models.

The main conceptual difference between the option value model and the dynamic programming approach is that in the option value model an individual compares the utility of leaving the military now with the maximum value of expected future utilities. In the dynamic programming models, the decision is based on the expected value of the maximum of current versus future options. An example will help clarify the difference.

For Air Force officers, retirement is mandatory (with few exceptions) after 30 years of service. After the 29th year of service, the separation decision is thus based on comparing the utility of leaving with the utility of serving one more year and retiring after 30 years of service. At this point, the decision rule for the option value model and the dynamic retention model are the same: the option value model decision maker compares the expected value of retiring with the expected value of working one more year and then retiring, and makes the choice with the maximum value. The dynamic decision maker does the same thing, and we will call the value of this decision W_{29}.

After 28 years of service, the decision rules are different. The option value decision maker compares the expected values of separating after 28, 29, and 30 years of service, and makes the decision based on the maximum of these. The dynamic programming rule has the decision maker comparing the value of leaving after 28 years of service with the value of serving one more year and then making decision W_{29}. Since in year 28 the actual circumstances of the 29th year are not known, the decision is based on the expected value of W_{29}, which is the maximum of two random variables. For any year $t<28$, an individual can in theory calculate recursively the value of remaining in the service and receiving W_{t+1} from future "correct" decisions.

Again, analogous to the option value specification, assume that an individual's utility from Air Force employment in year s is

$$U_M(s) = Y_s^{\gamma} + \Gamma + \epsilon_{1s} \quad (17)$$

and utility from leaving for a new job is

$$U_C(s) = [C_s(r) + kB_s(r)]^{\gamma} + \epsilon_{2s}. \quad (18)$$

The term Γ is a random additive taste for military employment, and is assumed to be distributed as $N(0,\lambda^2)$. If $\lambda=0$, as we will assume in this paper, there is no random taste factor. The disturbance terms are random perturbations to the utilities in a given year of service, and are assumed to be known to the individual at time t. Unlike the option value errors, these are assumed to be independent over time. The estimation procedure is described in an appendix.

III. RESULTS

A. Parameter Estimates and Comparisons

Table 1 shows the utility function parameters obtained for the three models of retirement behavior . An easy way to compare the results of the three models is to graph the actual and predicted voluntary loss rates for the pilot population under consideration.[5]

The top panel of Figure 1 shows the actual and option value predicted 1988 voluntary loss rates of pilots in the sample. The bottom panel shows the implied cumulative voluntary loss rates. Both panels include a 95% confidence interval around the actual rates.

[5]The voluntary loss rate in year t is the percentage of pilots without any service obligation in year t who are not present in year t+1.

The option value model predictions fall outside the 95% confidence interval only at 7, 8, 9, and 23 years of service. The model underestimates the departure rates at 7 and 8 years of service; pilots in these years are just completing their initial service obligations for pilot training, and many may be leaving because they realize that military flying is not to their liking. A difference in the characteristics of the pilot population still within a year or two of completion of the initial service obligation and the population that remains after the initial obligation would help explain the inability of the model to pick up the large initial departures.

Promotion to the rank of major occurs sometime after the eleven year point in an officer's career. Those who accept promotion are obligated to remain in the service for two more years; those who refuse promotion will leave, and those who do not receive the promotion may decide to leave rather than try for promotion at a later date. The jump in actual departures at the twelve year point seems to be a result of those who are leaving after not accepting (or not receiving) the promotion to major. The model may not pick up this increase because the decision made here involves non-pecuniary factors such as lack of desire to be committed beyond 12 years of service.

It is striking that the model captures rather well the wide jumps in departure rates between 20 and 28 years of service.

By way of comparison, Figures 2 and 3 show the predicted voluntary loss rates using the dynamic programming and ACOL models. Although the dynamic programming formulation matches the data about as well as the option value for persons with less than 20 years of service, it underpredicts the large increase in departures at 20 years, and is much less successful at following retirement patterns after 20 years of service. The ACOL model substantially overpredicts loss rates in the early years of service, does not pick up the large increase in departures after 20 years of service, and does not follow at all the pattern of changes in departure rates after 20 years of service.

We have two "out-of-sample" tests of the predictive power of the models investigated here. The first uses the parameters for the MAC and SAC pilots to predict the loss rates for Tactical Airlift Command (TAC) pilots in the initial sample; the second uses the 1988 parameters to predict 1989 SAC and MAC loss rates after the introduction of Aviator Continuation Pay.

Figure 4a compares the actual voluntary loss rates of TAC pilots in 1988 with the predicted rates using the option value and dynamic programming models. Figure 4b compares the predictions of the option value and ACOL models. As with the in-sample comparisons, the option value and dynamic programming models yield very similar predictions before 20 years of service, but after 20 years of service the option value model follows the actual departure pattern much better than the dynamic programming model. The ACOL model predictions are much worse than the other two.

Figures 5 and 6 compare the predicted 1989 departure rates using 1988 parameter estimates. The top graph in each figure shows the option value model predictions (both with and without the introduction of the bonus). Again, the option value and dynamic programming models are very similar until the 20 year point, after which the option value predictions are much closer to the actual departure rates. The ACOL predictions are the furthest from the actual rates. In addition, the ACOL model predicts a much larger reduction in departure rates as a result of the bonus payments than either the option value or dynamic programming models. [6]

The importance of the improved predictive capability of the option value model from a policy perspective is apparent in Figure 7. The top panel of the figure compares the potential effects of the 1986 change in the military pension predicted by the option value model to those predicted by the ACOL model.[7] Numbers below the zero reference line mean that pilots will leave because of the change; numbers above it mean that more will stay. For example, at 12 years of service, the option value model predicts that almost 100 pilots will leave because of the new pension plan, while the ACOL model predicts that only 10 will leave. What is most important here is that the changes in pension benefits may affect officers at an earlier stage in their career than previously expected. The ACOL model shows very little effect until after 12 years of service; the option value model shows large effects as early as 7 years of service. Using 1987 pilot populations, the option value model shows the Air Force losing 714 pilots in the seven to nineteen years-of-service cohorts under the new system, while the ACOL model shows a loss of only 229. The possibility of the pension change having larger effects on younger military members was raised by Argüden

[6]The introduction of ACP did not produce the desired reduction in pilot losses. The Air Force view is that those who accepted the bonus were planning to remain in the service anyway. However, the bonus is not viewed as a failure. Those who accept the bonus incur a service commitment, and so Air Force personnel planners know which pilots will not be able to leave the military in future years.

[7]This was done by assuming that the relative changes in departure patterns caused by the pension change in the sample are representative of the changes that would be observed in the entire pilot population. The simulation assumes that pilots present in 1987 are suddenly faced with the prospect of being subject to the new pension plan.

in [1] using the Gotz-McCall dynamic programming model with the Air Force enlisted population.

B. Potential Changes in Pilot Distribution

Using factors such as the expected number of aircraft available in future years and the number of crews required to fill them, the Department of Defense and the Air Force develop an "objective force" as part of the five-year defense plan to show the desired distribution of pilots by years of service. Decisions concerning changes in the management of the pilot force are made with the objective force structure in mind.

Figure 8 shows the 1994 objective force (taken from the DoD Aviator Retention Study), the actual distribution of pilots by years of service in 1990, and the distribution of pilots if the departure rates of 1990 continued for the next four years. The figure assumes that 1600 pilots complete pilot training each year. Compared to the objective force, current pilot levels are low in all years except 5,6,7, and the years after 15. With the 1990 departure rates, the shortages will increase in all years from 6 through 19, and, of course, this is the problem that the pilot bonus was meant to solve.

We noted in Section III.A that the implementation of Aviator Continuation Pay did not have the desired effect on pilot retention rates. We have attempted to devise a bonus that would induce the departure rates necessary to maintain the 1994 objective force. We do this by noting the percentage decrease in 1990 departure rates necessary to reach the 1994 steadystate rates and determining the bonus necessary to achieve this decrease of departure rates in the 1988 sample of MAC and SAC pilots.[8]

The result of this exercise is shown in Figure 9. The best fit using a new bonus amount requires that current bonuses be increased 6-fold - that is, for a pilot who has completed six years of service, the annual bonus for the next eight years needs to be $72,000 instead of $12,000! The population changes over the five year period from 1990 to 1994 lead to the distribution in the figure. The pilot shortages from 7 years of service to 12 years of service are largely reduced (overcome more than we want in 9, 10, and 11), but shortages continue from 13 years on. This would obviously be an extremely expensive program.

If we assume that the pension plan change that affects military members who entered the service after Aug 1986 were suddenly applicable to pilots present in 1990, the long-term effects of the decrease in pension compensation result in the distribution of Fig 10. Pilot shortages increase from eight years of service through 19 years of service, then surpluses exist through 27 years of service.

IV. CONCLUSIONS

The option value model captures Air Force pilot departure behavior much better than the Annualized Cost of Leaving model that has been used by the Military, and substantially better than a more complex stochastic dynamic program specification. The superiority of the option value model to the dynamic programming formulation raises the possibility that individual decision making may not always be best modeled with a model that is intended

[8]We assume that the new bonuses are a constant multiple k of the current bonuses available. The k that produces the best fit (in a least squares sense) to the desired departure rates gives us the new bonuses.

to approximate "correct" economic financial calculations. This is consistent with the results of Lumsdaine, Stock, and Wise [17].

Predictions of the effects of changes in compensation using the option value model indicate that individuals at early stages in their careers are more sensitive to losses of future benefits than indicated by previous models. The effects of temporary annual bonuses such as ACP are small - and bonus amounts must be extremely large to induce departure rates that come close to achieving the 1994 objective force.

The extraordinary changes in the world's political and military climate since the summer of 1991 will lead to adjustments in the defense structure of the United States. Already, decreases in the defense budget have led to a drop in the planned number of Air Force tactical fighter wings and a 25% decrease in the number of cockpits available for pilots. Entries into undergraduate pilot training will be reduced by 270 pilots per year starting in 1992, and the total number of pilots in the Air Force is expected to be down from over 21,000 in 1990 to 16,500 in 1997.[9]

Overall Air Force strength is projected to decrease markedly in the next few years — from 545,000 personnel in 1990 to approximately 415,000 by 1995. To encourage people to leave the service, the Air Force instituted two incentive programs in 1992. The first, called the Voluntary Separation Incentive (VSI) provides an annual payment to an individual (payment based on base pay and number of years of service) that will last for twice the number of years the individual has been in the service. For example, a major with 16 years

[9]These figures for pilot reductions were reported in the July 15, 1991 Air Force Times.

of service could leave the Air Force and receive an annual payment of $17,466 for 32 years (a present value of $236,343, according to the Air Force).

The second, called the Special Separation Benefit (SSB) is a lump sum payment that is 15% of an individual's base pay multiplied by the number of years served. The major mentioned above would receive a one time SSB payment of $104,795.

Both programs were introduced with little econometric modeling of their potential effects, and fewer officers than expected applied to accept either program.

As the Air Force and the other services struggle to reduce in size, other separation incentives will be proposed and studied. The procedure discussed here may be useful in predicting their effects.

REFERENCES

[1] Argüden, Yilmaz R. *Unintended Effects of the New Military Retirement System.* Rand Note N-2604-AF. Santa Monica, CA, May 1987.

[2] Ausink, John A. "The Effect of Changes in Compensation on a Pilot's Decision to Leave the Air Force". Unpublished PhD Dissertation, Harvard University, May 1991.

[3] Baldwin, Robert H., and Thomas V. Daula. "Modeling the Retention Behavior of First Term Military Personnel: Methodological Issues and a Proposed Specification". *Research in Labor Economics*, Volume 7, 1985, pp. 339-363.

[4] Baldwin, Robert H., Thomas V. Daula, and D. Alton Smith. "Military Manpower Research: An Introduction". *Research in Labor Economics*, Volume 7, 1985, pp. 257-338.

[5] Bartholomew, Herbert A. *Military Compensation Background Papers: Compensation Elements and Related Manpower Cost Items, their Purposes and Legislative Backgrounds*. 2nd Edition. Washington, DC: Department of Defense, Office of the Secretary of Defense. July 1982.

[6] Bowman, Major Charlie T. Aviator Continuation Pay Memorandum. HQ AFMPC/DPMATM, Randolph AFB, TX. 3 Oct 1990.

[7] Congressional Budget Office. *Alternative Compensation Plans for Improving Retention of Air Force Pilots: A Special Study*. Washington: GPO, August, 1989.

[8] Daula, Thomas V. and Robert A. Moffitt. "A Dynamic Model of Enlisted Retention Behavior in the Army". Unpublished manuscript, April 1989.

[9] ____________. "Estimating Dynamic Models of Quit Behavior: The Case of Military Reenlistment." Unpublished manuscript, July 1992.

[10] Department of Defense. *Fifth Quadrennial Review of Military Compensation.* (QRMC V), 6 vols. Washington: GPO, January 1984.

[11] ___________. *Department of Defense Aviator Retention Study - 1988.* Washington: GPO, November 28, 1988.

[12] ___________. "Report of the Secretary of Defense". January 17, 1989.

[13] ___________. "Department of Defense Annual Report, 1989".

[14] Gotz, Glenn A. and John J. McCall. *A Dynamic Retention Model for Air Force Officers.* Rand Corporation Report R-3028-AF. Santa Monica: December, 1984.

[15] Hogan, Paul F. and Marjorie Goon. "An Econometric Analysis of Air Force Officer Retention: Reestimation of the DOPMS Model". Unpublished draft of report to Air Force Office of Personnel, June 1989.

[16] Kmenta, Jan. *Elements of Econometrics.* New York: McMillan Publishing Company, 1986.

[17] Lumsdaine, Robin L., James H. Stock, and David A. Wise. "Three Models of Retirement: Computational Complexity versus Predictive Validity," in D. Wise (ed.), *Topics in the Economics of Aging.* Chicago, IL: University of Chicago Press, 1992.

[18] Norris, Major James M. "The DPAC Compensation Model: An Introductory Handbook". Maxwell AFB, AL: Air Command and Staff College, 1987.

[19] Stock, James H. and David A. Wise. "Pensions, the Option Value of Work, and Retirement". *Econometrica* vol 58, No 5. September 1990, pp. 1151-1180.

[20] Warner, John T. *Alternative Military Retirement Systems: Their Effects on Enlisted Retention.* Alexandria, VA: Center for Naval Analysis, September 1979.

[21] Wise, David A., ed. *Pensions, Labor, and Individual Choice.* Chicago: University of Chicago Press, 1985.

APPENDIX ON STOCHASTIC DYNAMIC PROGRAMMING MODEL

In year t, the individual makes the decision to stay or leave based on the value function W_t given by

$$W_t=\max\left[E_t(Y_t^\gamma+\Gamma+\epsilon_{1t}+\beta W_{t+1}),\ E_t(\sum_{s=t}^{T}\beta^{s-t}(C_s(t)+kB_s(t))^\gamma+\epsilon_{2t})\right] \tag{A1}$$

where β is the discount factor and T is the time of death. The first expected value in the brackets is that of remaining in the service one more year and then making the best decision in year t+1; the second term is the expected value of leaving now.

Since the disturbances are independently and identically distributed, $E_t\epsilon_{i,t+s}=0$ for $s>0$. With this fact, and again taking into account the probability of surviving to year s given a person is alive in year t, we can write

$$W_t=\max\left[W^*_{1t}+\epsilon_{1t},W^*_{2t}+\epsilon_{2t}\right], \tag{A2}$$

where

$$W^*_{1t}=Y_t^\gamma+\Gamma+\beta\pi(t+1\mid t)E_tW_{t+1} \tag{A3}$$

and

$$W^*_{2t}=\sum_{s=t}^{T}\beta^{s-t}\pi(s\mid t)(C_s(t)+kB_s(t))^\gamma \tag{A4}$$

An individual will decide to leave the military if

$$W^*_{1t}+\epsilon_{1t}<W^*_{2t}+\epsilon_{2t}, \tag{A5}$$

and so the probability of leaving in year t is

$$Pr[W^*_{1t}+\epsilon_{1t} < W^*_{2t}+\epsilon_{2t}] = Pr[\epsilon_{1t}-\epsilon_{2t} < W^*_{2t}-W^*_{1t}]\,. \tag{A6}$$

If we assume that the ϵ_{it} are independent draws from a normal distribution with zero mean and variance σ^2, the variance of $(\epsilon_{1t} - \epsilon_{2t})$ is $2\sigma^2$, and we can write equation A6 as

$$Pr[R=t] = Pr\left[\frac{(\epsilon_{1t}-\epsilon_{2t})}{\sqrt{2}\,\sigma} < \frac{(W*_{2t}-W*_{1t})}{\sqrt{2}\,\sigma}\right] = \Phi(a_t) \tag{A7}$$

where Φ is the cumulative normal distribution function and

$$a_t = \frac{(W*_{2t}-W*_{1t})}{\sqrt{2}\,\sigma}.$$

To find this probability, we need to get an expression for the recursive part of the function W_t, that is $E_{t-1}W_t$. This can be shown to be

$$E_{t-1}\left(\frac{W_t}{\sigma}\right) = \frac{W*_{1t}}{\sigma}(1-\Phi(a_t)) + \frac{W*_{2t}}{\sigma}\Phi(a_t) + \sqrt{2}\,\phi(a_t) \tag{A8}$$

where ϕ is the standard normal density function.

In equation A8, $\Phi(a_t)$ represents the probability that the individual leaves the military and receives utility $W*_{2t}$, and $(1 - \Phi(a_t))$ represents the probability that the decision is made to remain and receive utility $W*_{1t}$. The remaining term comes from the expectation of the disturbances. In sum, we use equation A8 to recursively calculate the values of W^*_{1t} and W^*_{2t}, and then use equation A7 to calculate the probability of retirement.[10]

The error structures of the option value and dynamic programming approaches are similar, but arise from different assumptions. In both cases, future errors are normally distributed with non-zero covariance. This is the result of the Markov assumption for the generation of the errors in the option value model, but comes from a "components of variance structure, with an individual specific effect" ([17], p. 14) in the dynamic programming model.

[10]When no taste factor is used, this is all that is needed in the estimation. When the taste factor is allowed, it is also necessary to integrate over the taste distribution. This integration substantially increases the computation time for the dynamic programming model.

TABLE 1

PARAMETER ESTIMATE SUMMARY

	Option Value Model		Dynamic Programming Model		ACOL
Parameter	(1)	(2)	(1)	(2)	
γ	1*	1.82 (.056)	1*	1.81 (.207)	
k	3.32 (.032)	3.28 (.020)	1.59 (.238)	1.44 (.184)	
ρ	1*	1*	–	–	
β	.948 (.005)	.896 (.006)	.852 (.012)	.852 (.012)	
σ	.893 (.012)	.754 (.028)	.413 (.031)	1.39 (.351)	
α_0					.669 (.075)
α_1					5.01 (.007)
Summary Statistics					
-log $\mathcal{L}$	505.9	496.4	509.3	501.1	529.9
χ^2	50.9	29.3	72.3	52.7	70.0

* Parameter fixed
Estimation is by maximum likelihood. Numbers in parentheses are asymptotic standard errors.
Monetary values are in $100,000 1986 dollars.
Note that σ for option value model and dynamic programming model are not comparable.

For the above table, the χ^2 goodness of fit statistic is calculated as

$$\chi^2 = \sum_{j=7}^{j=28} n_j \frac{(r_{aj} - r_{pj})^2}{r_{pj}}$$

where r_{aj} is the actual departure rate for those with j years of service, r_{pj} is the predicted departure rate for those with j years of service, and n_j is the number of individuals who have completed j years of service.

Figure 1
Actual and Predicted 1988 Voluntary Loss Rates

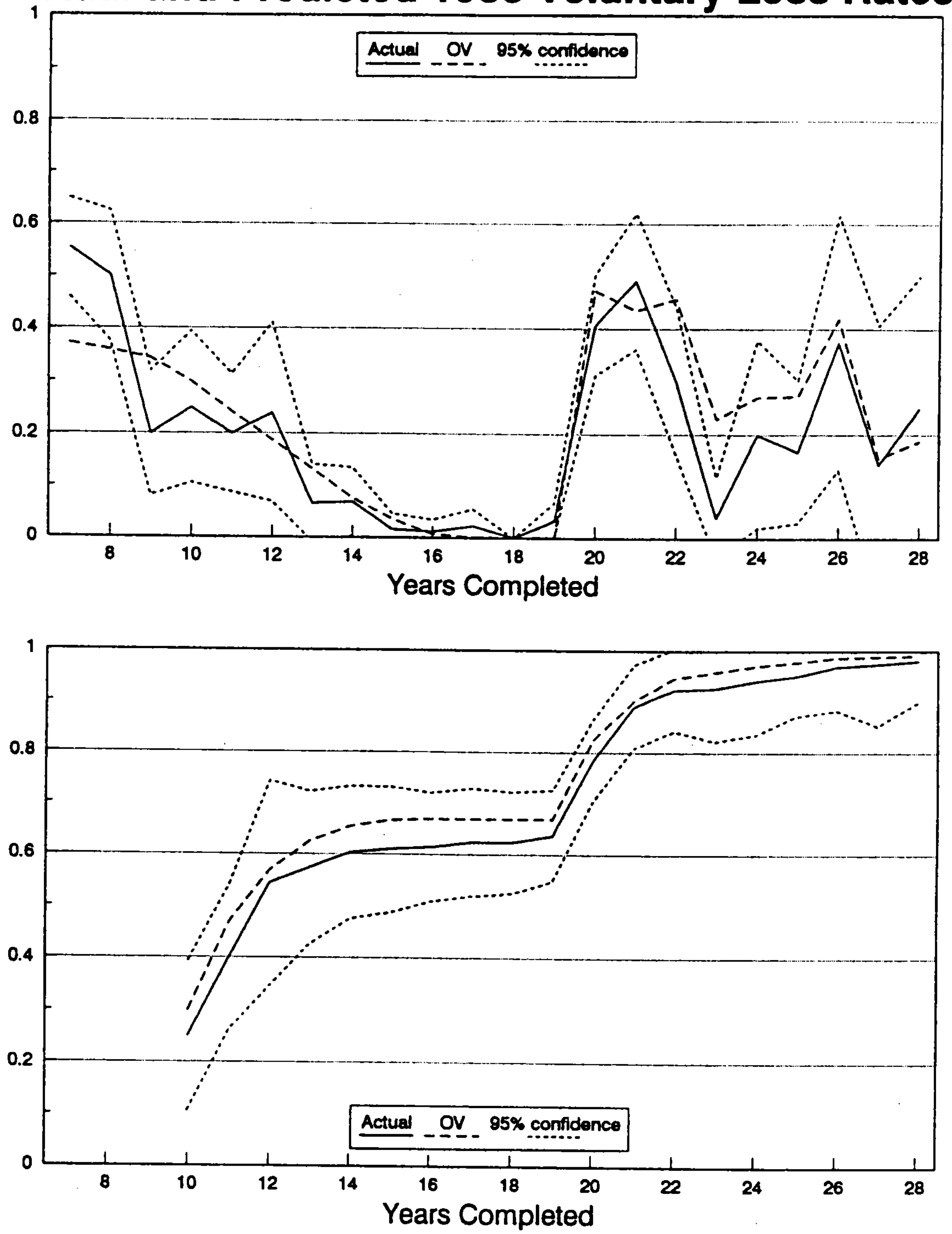


Figure 2
Actual and Predicted 1988 Voluntary Loss Rates

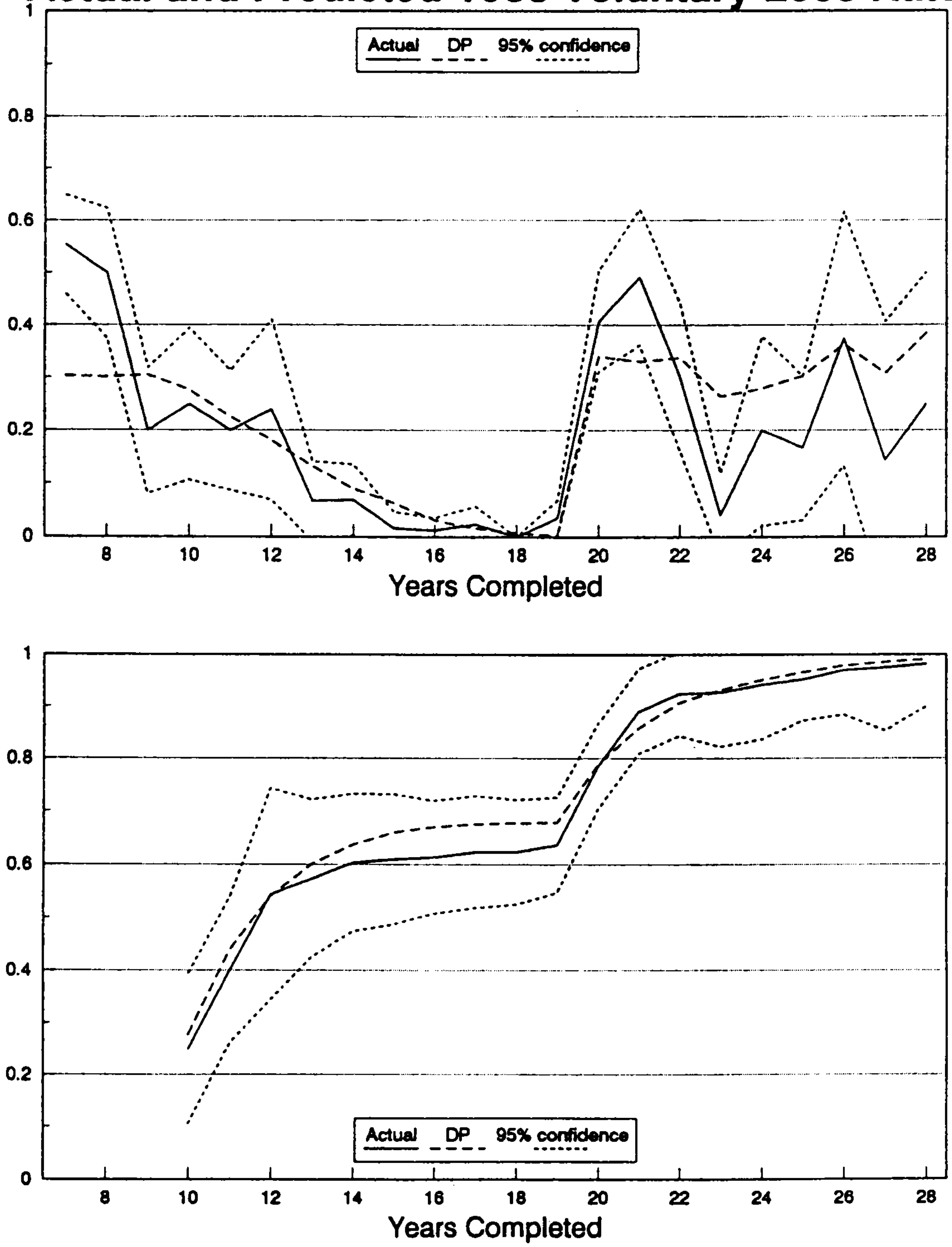
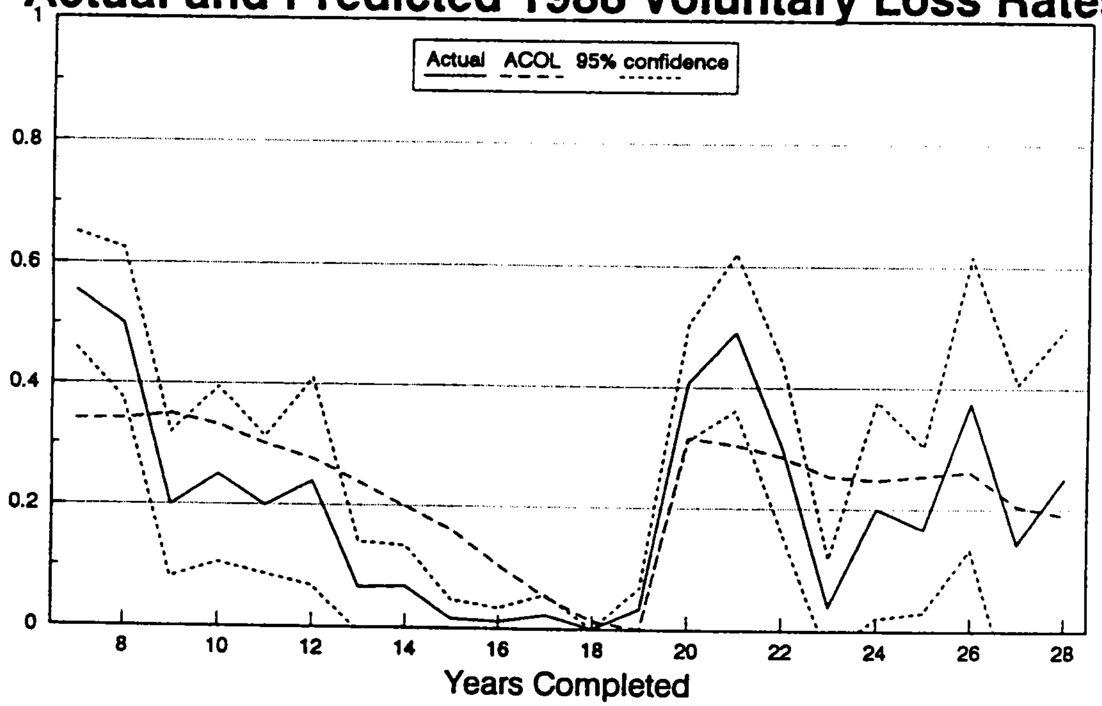


Figure 3
Actual and Predicted 1988 Voluntary Loss Rates



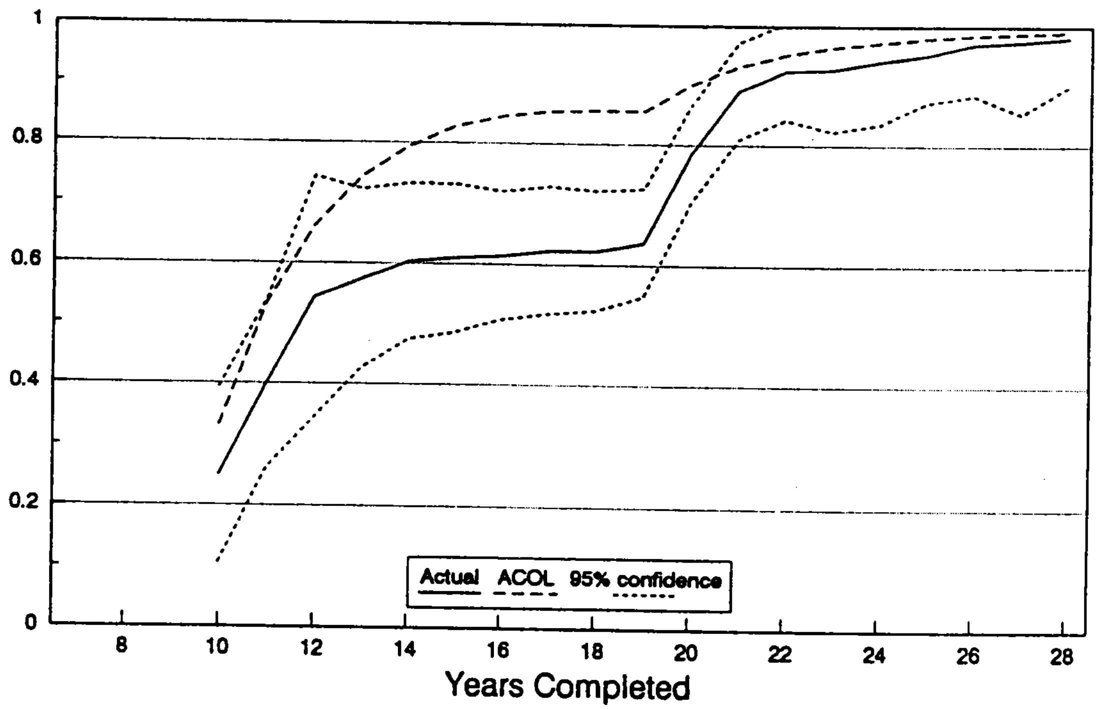
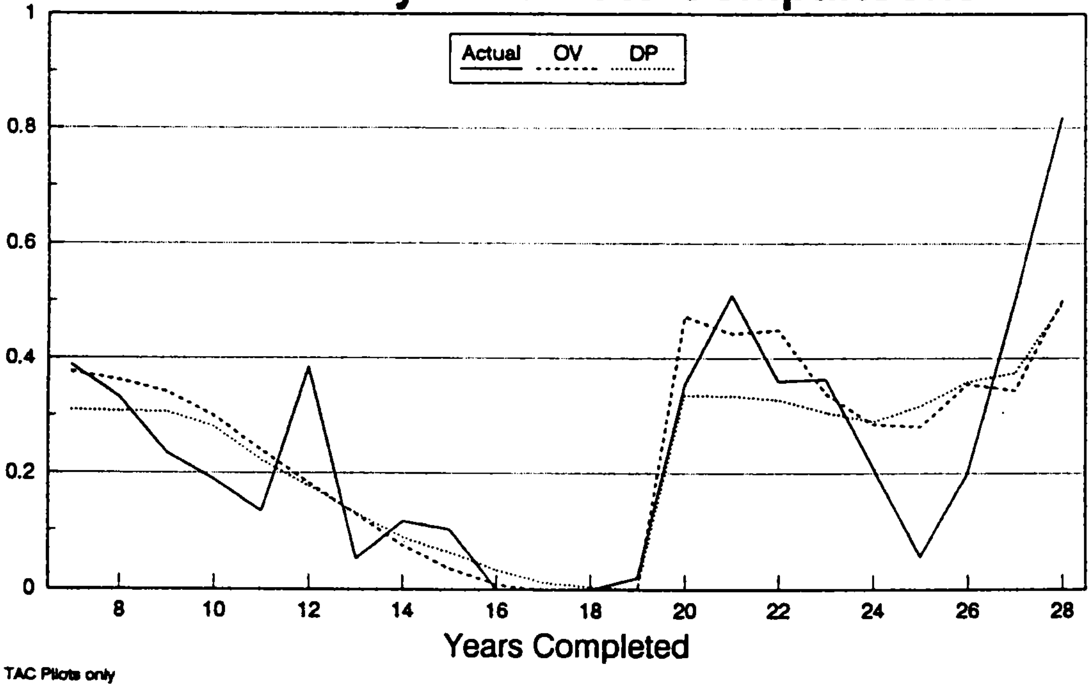


Figure 4
TAC Voluntary Loss Rate Comparisons



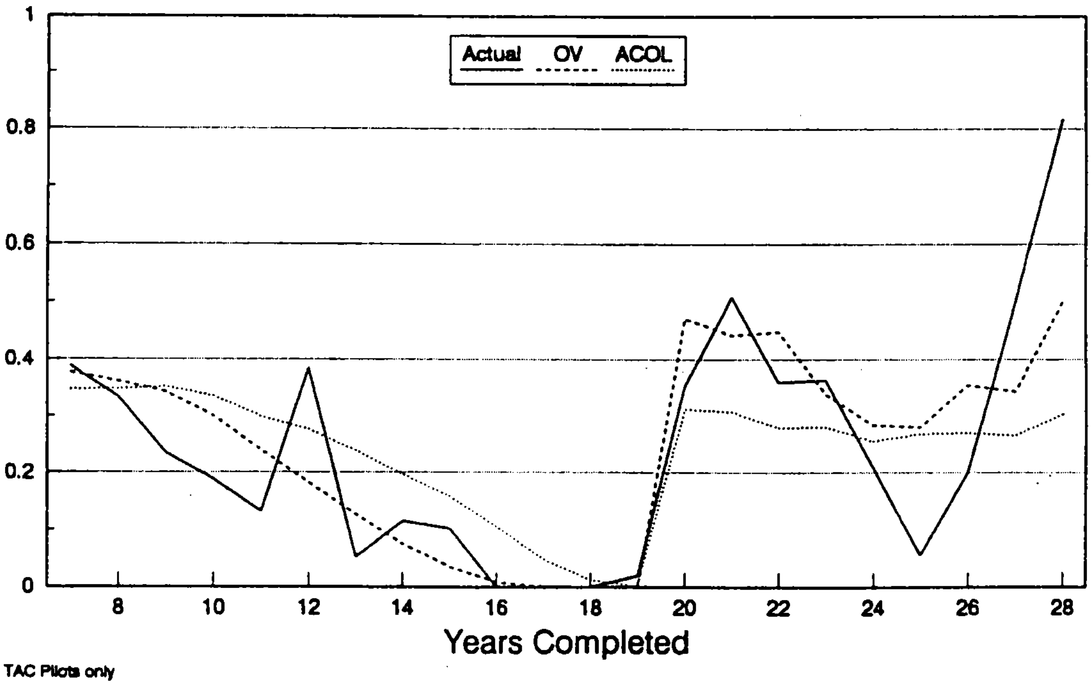
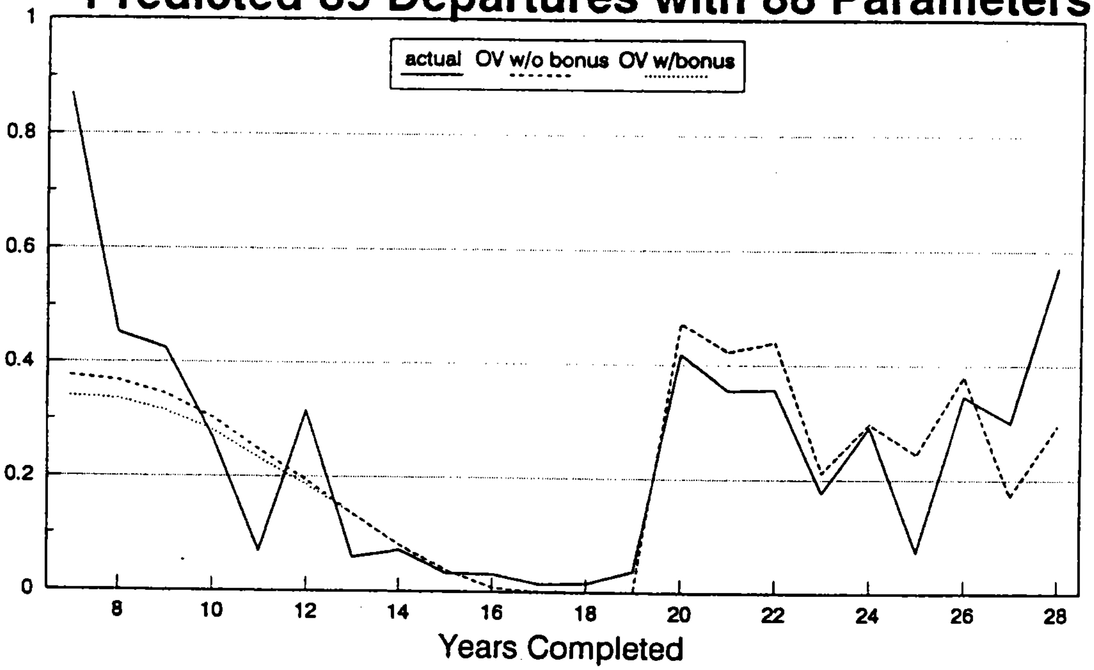


Figure 5
Predicted 89 Departures with 88 Parameters



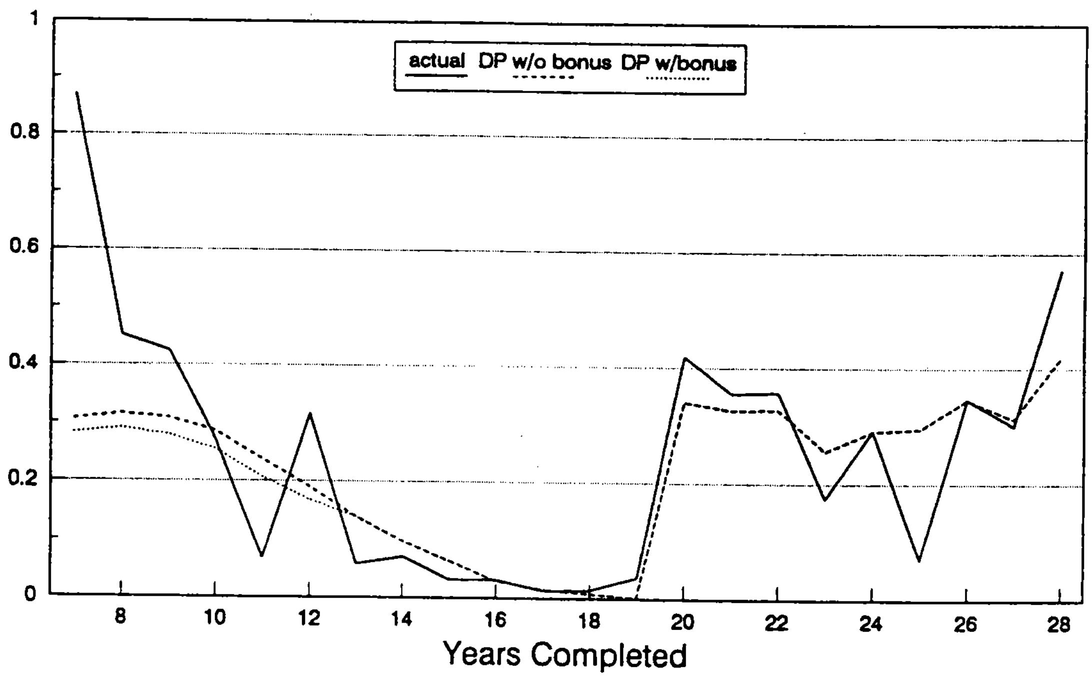
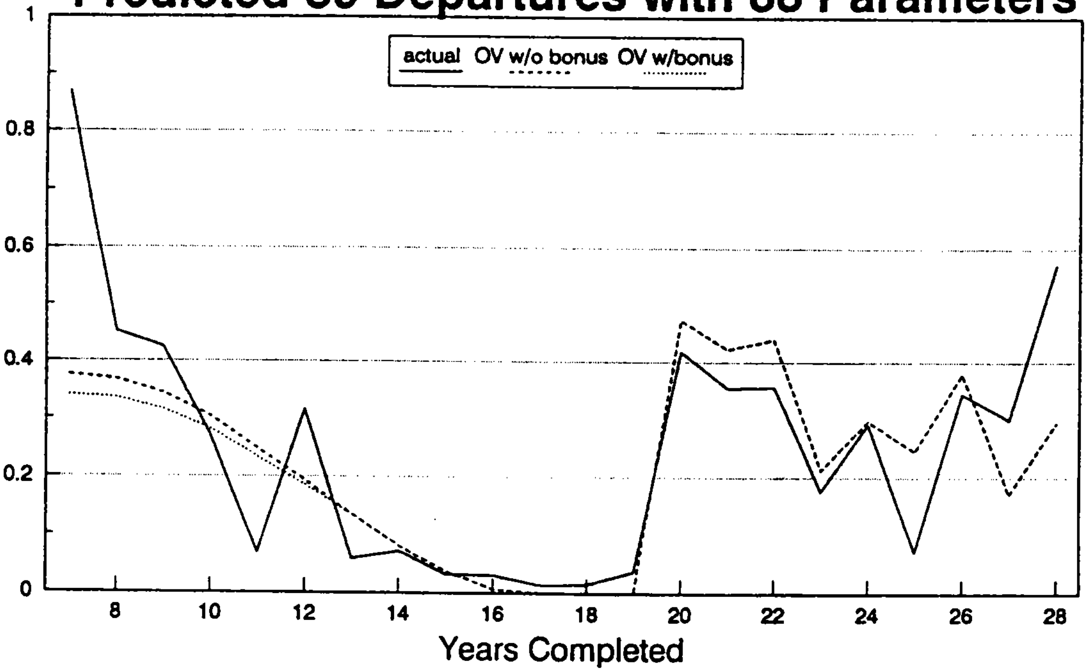


Figure 6
Predicted 89 Departures with 88 Parameters



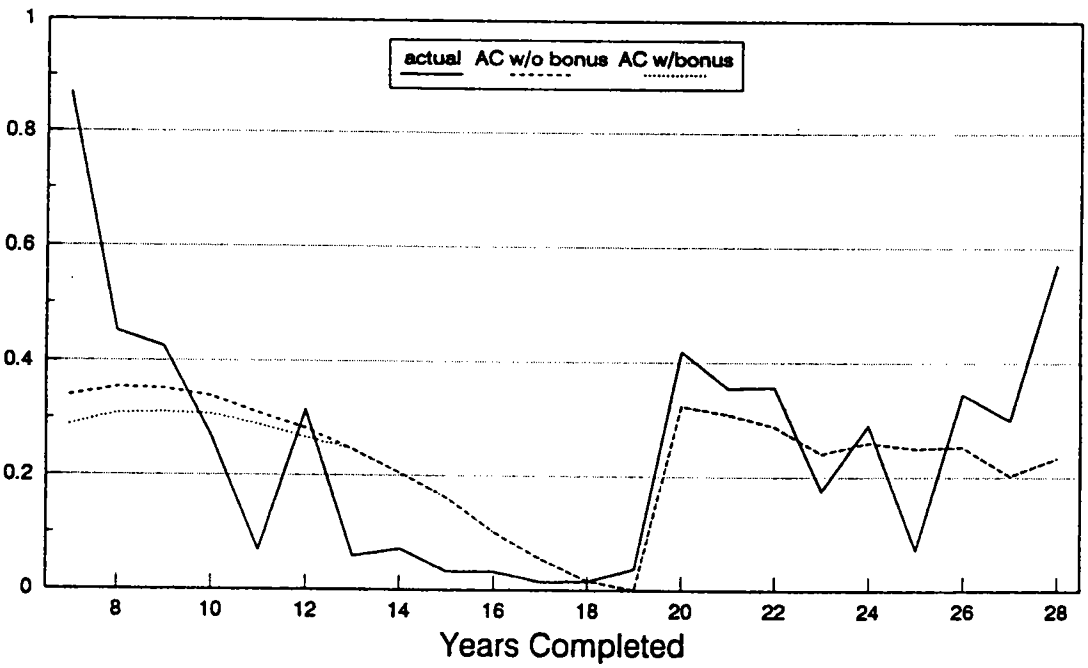
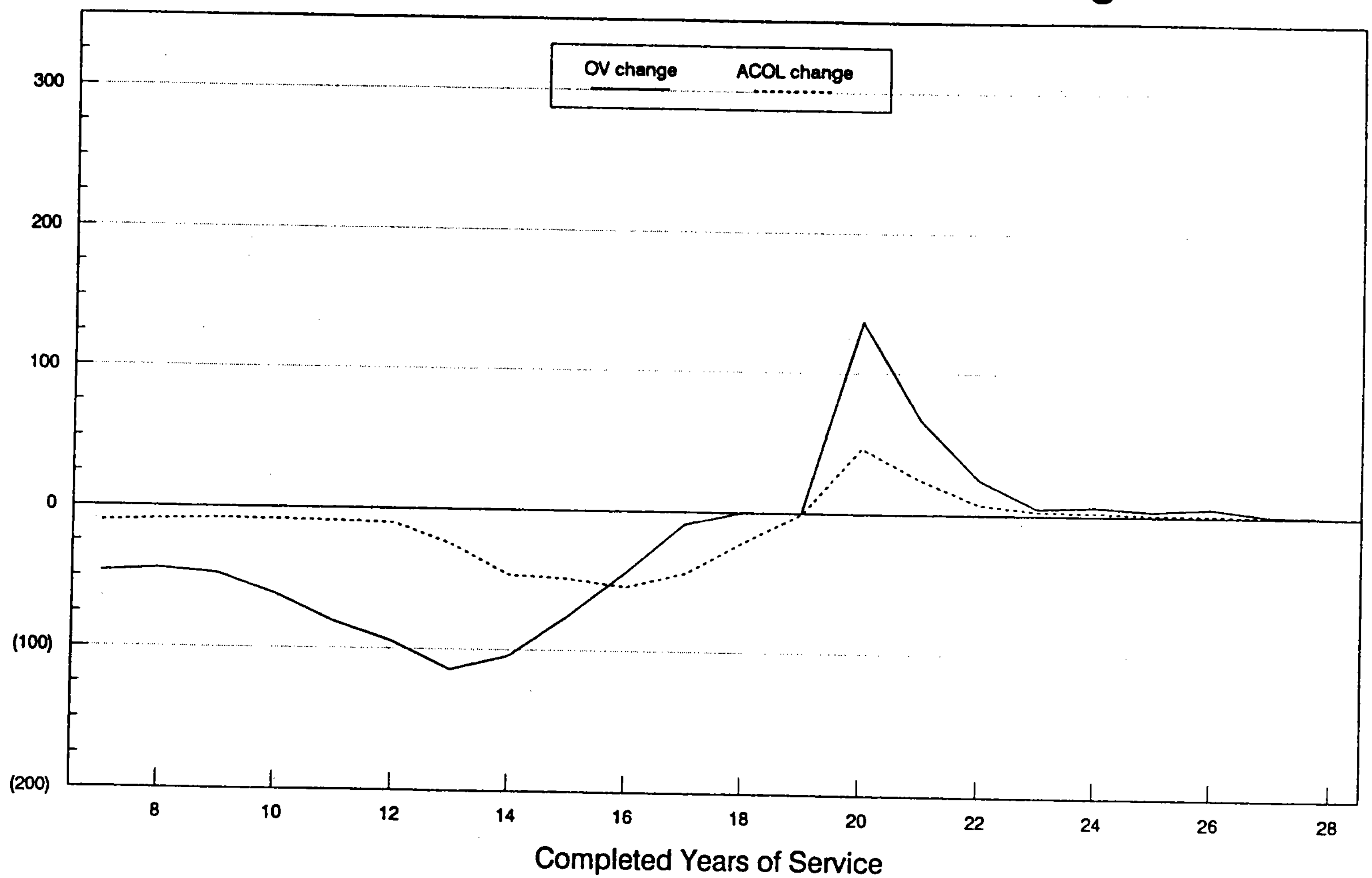


Figure 7. Potential Effect of Pension Change



Using total 1987 pilot population

Figure 8. Population in 1990 and 1994 Assuming 1990 Departure Rates

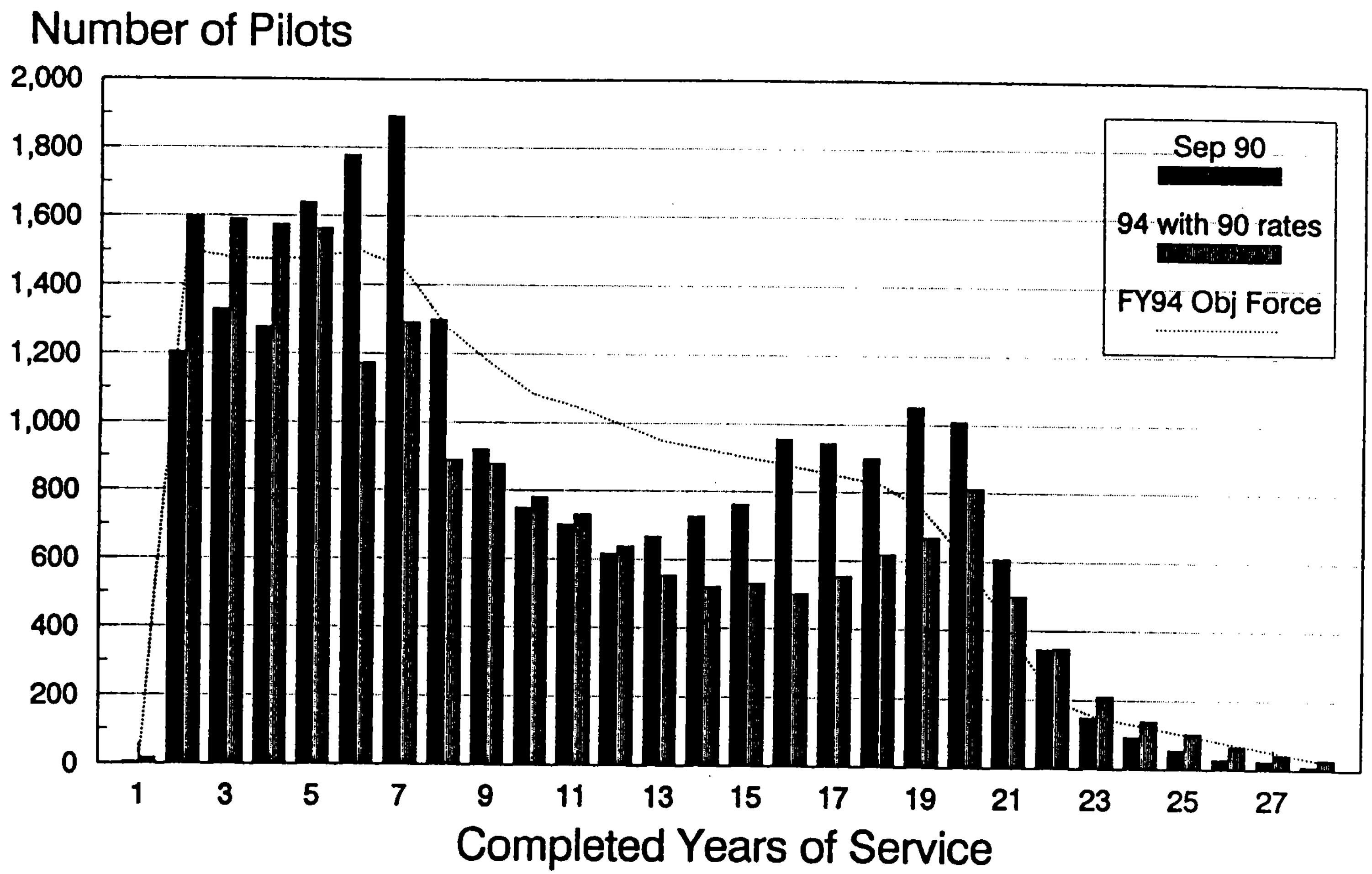
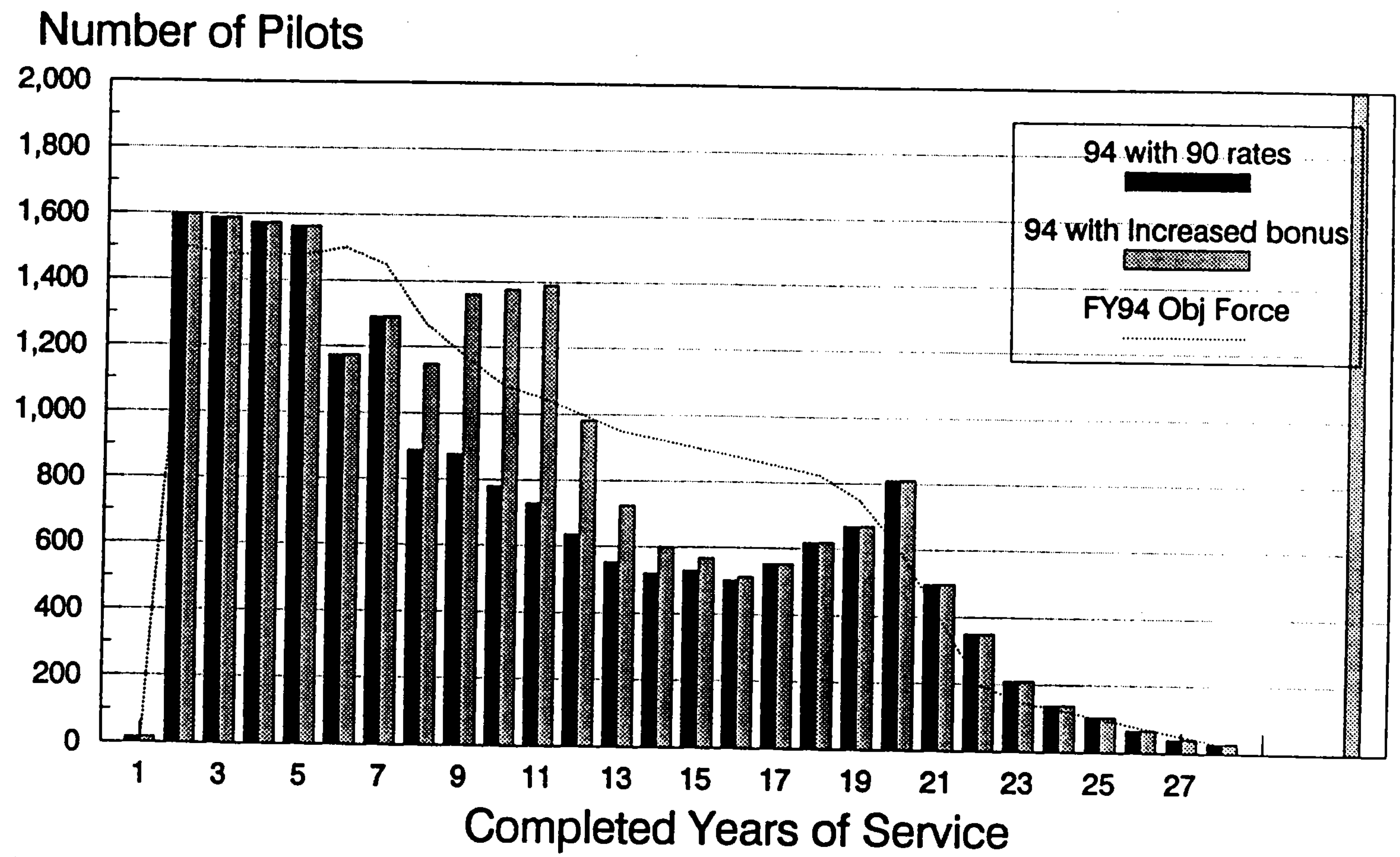


Figure 9. Population in 1990 and 1994

90 Departures vs Increased Bonus



Base Total: 18,911 New Total: 21,552

Figure 10. Population in 1990 and 1994

90 Departure Rates vs New Pension Rates