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The Effect of Changes in Compensation On a Pilot's Decision to Leave the Air Force

A thesis presented

by

John Arthur Ausink

to

The Committee on Higher Degrees in Public Policy

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ABSTRACT

Adviser: Professor David A. Wise

The effects of changes in military compensation on the decision to leave the Air Force are analyzed for a sample of Air Force pilots. Three models of departure behavior are compared: the Annualized Cost of Leaving (ACOL) model, which is frequently used by the Department of Defense, a dynamic programming model based on the work of Daula and Moffitt, and the "option value" model developed by Stock and Wise. The option value model is shown to produce predictions of departure patterns that are far more accurate than the ACOL model while being as accurate, but easier to estimate than, the dynamic programming model.

Aviator Continuation Pay (ACP) was introduced in 1989 to improve pilot retention in the Air Force, and was justified in part by retention effects predicted with ACOL models. The option value model predicts some improvement in pilot retention with ACP, but less than predicted by the ACOL model. This is closer to the actual effect.

Several variations of the military pension are simulated, and the effects of the 1986 pension change are predicted using the ACOL model and the option value model. Option value model analysis indicates that far more pilots in the early stages of their careers will be induced to leave the military because of the pension change than predicted by the ACOL model. This could have important implications for future military force management. (25 *Compensation, *Cost analysis, *Careers, ACOL (Annualized Cost of Leaving). -

Therefore, we must make ourselves indifferent to all created things, as far as we are allowed free choice and are not under any prohibition.

Consequently, as far as we are concerned, we should not prefer

health to sickness,

riches to poverty,

honor to dishonor,

a long life to a short life.

The same holds for all other things.

Our one desire and choice should be what is more conducive to the end for which we are created.

- St Ignatius of Loyola

To my parents and sister, who have shown me how to make choices.

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INTRODUCTION

From 1940 until 1973, most military manpower was provided, either directly or indirectly, by conscription [49]. This meant that the Department of Defense (DoD) seldom found itself competing with civilian labor markets for military personnel. With the introduction of the All Volunteer Force in 1973, the situation changed markedly, as the various branches of the armed services found it necessary to advertise themselves as attractive alternatives to civilian employment. Appeals to patriotism and the promise of adventure were not always enough to attract people to the military way of life, as military pay and benefits were perceived to be significantly lower than pay and benefits in loosely comparable civilian jobs. It was therefore a challenge for the services to meet recruitment quotas. In the battle to recruit sufficient numbers of soldiers and airmen to satisfy the defense needs of the country, the size and form of military compensation became increasingly important.

From Fiscal Year 1983 to 1989, military personnel costs increased from $73 billion to $78 billion in constant 1988 dollars ([20], p.325), and have accounted for approximately 25% of the Department of Defense budget in each of those years. It is no wonder that Congress, the Department of Defense, and the individual services are interested in ensuring that such a large sum of money be spent effectively in recruiting and retaining personnel.

Two of the most visible areas of concern in military compensation are the military retirement system and special bonus payments to specific skill groups to prevent their loss to civilian employment.

The Military Pension

As we will see in the first chapter, the military pension is widely perceived to be excessively generous and extremely expensive. Prior to 1985, when the government implemented an "accrual accounting" method for measuring the costs of pension outlays, most of the future obligations of the retirement system were not recognized in the Federal Budget, and Leonard [32] estimated that the net unfunded liability in 1983 represented a "hidden" debt 40 percent as large as the explicit national debt.

In the 1983 Fifth Quadrennial Review of Military Compensation (QRMC V), it was noted that nine commissions in the preceding 35 years had recommended changes to the system, but none of the changes had been made. This state of affairs is a reflection of the tension between the general military philosophy that the pension is a tool for recruitment and force management, and should not be modified without consideration of the possible effects on military force structure, and a common Congressional view that the pension should be treated more like civilian pensions and require less extravagant funding.

Bonuses for Specific Skill Groups

The military has traditionally provided extra pay for a variety of specialties to compensate for the added risk of exposure to unusually hazardous situations, but some special compensation packages have been introduced with the intention of inducing people to remain in the military despite economic pressure to return to civilian life.

Military pilots represent one group targeted for special pay. Retention of pilots is particularly important because of the high cost, in dollars and in time, involved in training them - almost $1.7 million dollars and more than 18 months for an Air Force fighter pilot [18] - and particularly difficult because of the opportunity for lucrative jobs in civilian airlines. Since 1983, airline hires have increased significantly, and increased losses of military pilots have followed them. With the airline hiring rates and pilot loss rates of 1989, the Air Force projected that it would have a shortage of more than 2900 pilots by Fiscal Year 1994. To address this problem, Aviator Continuation Pay (ACP) was introduced in 1989, which provided bonuses of up to $12,000 per year to pilots who agreed to remain in the Air Force through fourteen years of service. Congressional Budget Office estimates put the cost of the first four years of this program at about $94 million [12].

The Public Policy Problem

The military has an interest in adjusting compensation in ways to recruit the people it needs and retain the people it wants. The Congress has the same interest, but also the responsibility for authorizing changes in compensation and ensuring that changes are accomplishing the purposes that were intended. When considering changes in the pension system, Congress and the military must balance the potential savings with the potential effect on force structure. When contemplating a bonus for pilots, it is important to be able to predict the improvement in retention, and compare the savings in training costs for replacement pilots to the cost of the bonus.

The Department of Defense and the individual services have various computer models available to them to predict the retention effects of changes in compensation and required changes in recruitment that would follow, but there are two problems related to previous studies of the military pension and bonus pays to special skill groups. First, there has been only one significant change in the calculation of the military pension in the past 42 years, and it affects only those who joined the military after August of 1986. Some military officers who were commissioned after that time have yet to complete their initial service obligations; since they have not yet had the opportunity to leave the service, there are no observable changes in retention behavior that could be attributable to the change in the pension system. It is therefore difficult to confirm the accuracy of predicted effects of retirement changes.

Second, the introduction of Aviator Continuation Pay was justified with evidence from pilot surveys, previous experience with different bonus programs, and the same econometric models that have been used to study the effects of changes in the pension system. The actual acceptance rate for the bonus was well below what was expected, and the effect of the bonus on retention rates was minimal. There is therefore reason to doubt the reliability of the DoD retention models used.

The importance of having reliable models raises the issue of the tradeoff between the ability of a model to predict behavior accurately and the practical need to be able to estimate it. A complex model that attempts to capture subtle aspects of behavior may be computationally intractable, while simplifications that allow estimation may strip the model of explanatory power.

Dissertation Outline

This dissertation examines the performance of three different models of retention behavior for a population of Air Force pilots: the Annualized Cost of Leaving (ACOL) model used by the DoD and the Air Force, a dynamic programming model based on the work of Daula and Moffitt [15], and the option value model developed by Stock and Wise [42a]. We will see that the option value model performs much better than the ACOL model, and as well as the generally more computationally intensive dynamic programming model.

Chapters One and Two provide background and theory for this study. Chapter One covers some of the history and motivation for the form of the military pension and the structure of pilot incentive pay. Mathematical details of the models compared are explained in Chapter Two.

Estimation of the models and out of sample tests of their predictive capability are described in Chapters Three and Four. Model parameters are estimated for the departure behavior of a sample of pilots in the Air Force in 1988, and the ability of the various models to predict the consequences of the introduction of the pilot bonus in 1989 is compared.

Chapters Five and Six address some policy implications of the different effects of compensation changes predicted by the option value and ACOL models. Alternative pilot incentive pay plans are discussed in Chapter Five, and I argue that ACOL based analysis by the Congressional Budget Office may have overestimated their potential for improving pilot retention. Chapter Six uses the option value model to analyze the effects of pension changes that have been proposed in the past and the pension change that was introduced in 1986. The most important conclusion is that the option value model predicts greater losses of pilots early in their careers than the ACOL model does, and so it is possible that the savings anticipated by the introduction of the new pension plan could be offset by the need to recruit and train more replacement personnel than originally anticipated.

CHAPTER ONE

MILITARY COMPENSATION

Military compensation has three major components:

1. Pay and allowances

2. Special incentive pays

3. Supplemental benefits, the largest one being the retirement pension ([17], Executive Summary).

Since we are most interested in the retention effects of changes in pilot bonuses and retirement pay, this chapter covers some history and motivation behind those two components. However, some understanding of the other forms of military pay will be useful.

1.1 Pay and Allowances

The problem of adequately compensating service men and women did not originate with the All Volunteer Force. The goal of the Career Compensation Act of 1949 was to produce a pay system that would be "equitable to military personnel as well as responsive to the needs of the United States in terms of attracting and retaining the numbers and types of personnel needed during the period following WWII." ([5], p.6) To that end, the Act created a four-part structure that has remained unchanged to this day.

Basic Pay: This pay is received by all military members. The amount is determined by the individual's rank, years of service and the fiscal year. Basic pay is taxed as ordinary income.

Basic Allowance for Quarters (BAQ) and Variable Housing Allowance (VHA) Officers and enlisted personnel who are not furnished housing at government expense are allowed an allowance for quarters. The amount of the allowance depends on rank and whether or not the member has dependents.[1]

In the 1970s, military personnel assigned to parts of the country that were experiencing rapid increases in housing prices found themselves at a distinct financial disadvantage compared to their compatriots stationed in less expensive areas who were receiving the same BAQ. Congress recognized that people serving in high-cost areas "at the convenience of the government" should not be penalized for it, and authorized the Variable Housing Allowance (VHA) in 1980 ([5], p.57).

The VHA is paid to any member who is authorized to receive BAQ and assigned to a designated high housing cost area. Periodic surveys are conducted by the services to determine the average monthly housing costs for members in a given pay grade, and the VHA is calculated as the difference between the average monthly housing costs in the area of residence and 115 percent of the BAQ the individual receives ([5], p.57).[2]

Neither BAQ nor VHA is taxable.

---

[1]Until 1967, some enlisted members received varying amounts of BAQ depending on the number of dependents they had.

[2]A cap was put on VHA amounts in FY 1987.

Basic Allowance for Subsistence (BAS) This non-taxable allowance is supposed to "defray a portion of the cost of subsistence" of military members ([5], p.41) There is one rate for officers, one for enlisted. Historically, this allowance was meant to approximate the cost to the government of feeding personnel, but there is no longer any effort to base the level of BAS or its adjustments on such a relationship.

Special Incentive Pays There are approximately thirty-eight categories of special incentive pays in such diverse areas as submarine duty, deceleration subject duty, parachute duty, and (at least as late as 1983) leprosy duty. Like basic pay, the incentive pays are taxable.

Because of the tax-free nature of BAQ, VHA, and BAS, the Federal Government considers a non-cash "Federal Income Tax Advantage" to be part of military compensation. This is the additional amount of taxable income an individual would have to receive in a system which taxed the three allowances in order to be as well off as he or she is under the current tax system. The actual tax advantage that an individual realizes will depend on a wide variety of factors, such as tax filing status and level of non-military income, so the tax advantage imputed by the government is based on several simplifying assumptions ([5], p.69).

The tax advantage has been important because of two other pay definitions that are used when discussing policy issues. Regular Military Compensation (RMC) is defined to be Basic Pay, BAS, BAQ and VHA plus the associated tax advantage. Basic Military Compensation (BMC) is RMC minus the VHA and its tax advantage, and is what is usually used when policy makers try to discuss something comparable to a civilian salary.

From 1967 until 1974, the tax advantage was explicitly used in determining military pay raises in the following way: RMC was equated to civil service salary schedules, and when civil service salary levels increased, the basic pay of military members was increased so that the total RMC increased by a comparable amount. An example from the Zwick Commission ([49], p.26) will clarify what was going on. In 1967, civil service salary schedules increased by 4.5%. To achieve a 4.5% increase in RMC for comparable military members, basic pay had to be increased by 5.6%. This had important consequences in other areas, particularly in retired pay, which, as we will see, depends on a retiree's basic pay alone. Specifically, while military members received a 4.5% raise in 1967, people who subsequently retired saw a much higher increase in retirement benefits.

The law was changed in 1974 so that when civil service salaries were raised, basic pay, BAQ and BAS would be increased by the same percentage - in effect eliminating the formal link of the tax advantage to policy. Nonetheless, the concept is still used when Congress and the services attempt to gauge the equity of military compensation levels, and military financial advisers encourage people to take it into account when making the decision to leave the service for civilian employment. For the most part, however, service members seem to ignore or underestimate the tax advantage ([49], p. 103).

1.2 The Military Pension

Compared to most civilian pension plans, the military pension is both simple and generous. The structure of the 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. Table 1.1 describes the differences among them, and which military members are affected by them. The information is from Air Force Regulation 35-7, Chapter 7.

TABLE 1.1

CHARACTERISTICS OF CURRENT RETIREMENT SYSTEMS

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 1980 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 pay 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.

Two of the most notable characteristics of the military pension are that vesting occurs after twenty years of service and receipt of the pension begins immediately upon departure from the service. Anyone who voluntarily separates from the service before serving twenty years for reasons other than disability will not receive any retirement benefit. Officially, a "full" military career is considered to be thirty years of service, and the opportunity to retire after twenty years is a privilege granted at the discretion of the service, but in practice, requests to retire "early" are granted almost all of the time

[14]. For both officers and enlisted, twenty years of service is the most common time of retirement. In 1984, 1/3 of those who retired did so after completing 20 years of service.

Not everyone who would like to remain in the service long enough to earn a pension that is 75% of basic pay can, because the military's "up or out" promotion system places limits on the number of years that an individual can serve without a promotion. For example, in the Air Force, a major is generally first considered for promotion after 16 years of service. If the individual is not promoted, and also fails to be selected for promotion the next year, he or she will be involuntarily separated without receiving retirement benefits (though severance pay will be received). If the major is within two years of eligibility for retirement at the time of the second failure for promotion, he or she will be allowed to remain until the twenty year vesting point. There are provisions in the law which allow selective retention beyond twenty years for a major, but in no case will the officer be allowed to remain beyond 24 years (which would provide a pension of 60% of basic pay) ([17], vol 1).

The changes made to the pension for those entering the service after 1980 were an effort to reduce the cost of the system. Department of Defense figures show that for a typical lieutenant colonel who retired after twenty years in 1988, the present value of the Air Force pension would be $595,256 under the first plan (the "Final Pay" plan);

$553,223 under the second ("high three" plan) and only $445,000 under the most recent change.[3]

The constancy of the retirement system, and the relatively minor changes that were made in 1980 and 1986 are surprising in light of the fact that from 1967 to 1983 nine separate commissions and studies recommended more significant changes, and most of them were ignored. The reasons behind the lack of change are worth examining, because they raise the issues of the relative generosity of the pension plan in the United States and the philosophy behind the structure of military compensation.

The Cost of the Pension and Arguments for Change

From 1950 to 1986, the number of non-disability retirees in the United States increased from 58,752 to 1,179,005 ([21], p. 196), and the cost of providing pensions for these retirees increased from approximately $60 million per year to nearly $17 billion per year in nominal dollars [14]. According to the Congressional Budget Office, retirement costs nearly quadrupled in real terms from 1963 to 1984 [14]. As a final indication of the increased cost of the system, in Fiscal Year 1967, retirement benefits accounted for 2% of the defense budget ([49], p. 25). By 1983, (the last year the Department of Defense (DoD) annual report listed retirement pay as a separate line item), benefits were 8% of the defense budget ([20], p. 325). At that time, the

[3]As reported in the Air Force Times, 1 Aug 1988. The annual pensions would be approximately $22,152; $21,228; and $16,980 respectively.

President's Private Sector Survey on Cost Control (the Grace Commission) stated that retirement pay for military personnel was rapidly becoming unaffordable ([24], volume on the Office of the Secretary of Defense).

While concerns about the cost of the pension system have been raised in many studies, cost is not the only reason that some have argued for changes. The 1978 Report of the President's Commission on Military Compensation (the Zwick Commission) called the system inequitable, inflexible to the point of inhibiting effective force management, and inefficient because it has little influence on the decisions of prospective recruits when making their decision to join the military ([49], p 27).

One reason the system can be considered inequitable is that, as mentioned earlier, not everyone who serves in the military will receive a pension, because some who are not promoted rapidly enough will be forced to leave before they are vested at twenty years of service. In addition, many who are vested and would like to remain in the service long enough to receive the maximum pension will not be allowed to stay because they reach the tenure limit for their rank without receiving a promotion. The effect of these practices, as well as the fact that many people leave the military by choice before vesting, is that only about 12% of those recruited for active duty remain in the service long enough to become eligible for retirement pay [14]. In addition, fewer than 4% of the enlisted force serves for more than 20 years; the comparable figure for officers is 12%. Thus, the large costs of the retirement system provide benefits to only a small portion of people who have ever served in the military.

Another reason that the system can be considered inequitable is its generosity compared to military retirement systems in other countries and to civilian pension plans in the United States. Table 1.2 was put together by the General Accounting Office in 1983 to compare the military pension plan to two other federal plans and to the military plans of several other western countries ([14], p. 25). Table 1.3 shows a more recent comparison of military pensions and the civilian plans of medium and large American companies with defined benefit plans.[4]

[4]Defined benefit pension plans specify the benefits an individual will receive upon retirement. With defined contribution plans, an amount equivalent to a certain percentage of an individual's salary is put into a pension fund. Once vested, the amount the individual has in the fund depends on the amount that was contributed. Retirement benefits are based on the assets the individual has accumulated in the fund.

TABLE 1.2
LIFETIME RETIREMENT EARNINGS
UNDER VARIOUS RETIREMENT PLANS

	20-Year Retiree		30-Year Retiree	
	Enlisted	Officer	Enlisted	Officer
US Military	329	701	481	973
Federal Air Traffic Controller	302	688	434	886
Foreign Plans				
Australia	325	645	442	858
Canada	283	560	413	816
France	264	303	385	778
Israel	264	560	413	816
United Kingdom	*	897	280	827
W. Germany	255	500	432	807

* 20-year retirement not allowed

Estimates are in thousands of 1983 dollars.

Though there is wide variation in the provisions of civilian pension plans, it is important to note that in addition to the differences in value of the plans in tables 1.2 and 1.3, the military retiree can start to receive benefits as early as age 37 (for a person who enlisted at age 17 and served 20 years). The average age at retirement is about 42 for enlisted and 46 for officers [14]. Most civilian plans do not allow retirement at such a young age (age 55 is often considered "early" retirement, and benefits are rarely received if an employee leaves a firm at an earlier age).

TABLE 1.3

COMPARISON OF CIVILIAN PENSION BENEFITS AND COMPARABLE MILITARY BENEFITS

ANNUAL SALARY	AVERAGE CIVILIAN PENSION	COMPARABLE MILITARY PENSION
$25,000 after 20 years	$4,725/year	$9,126/year[1]
$25,000 after 30 years	$6,900/year	$17,493/year[2]
$40,000 after 20 years	$7,680/year	$15,555/year[3]
$40,000 after 30 years	$11,000/year	$23,333/year[4]

[1] Based on E-6 (Air Force Technical Sergeant) BMC of $25,430
[2] Based on W-1 (warrant officer) BMC of $26,379
[3] Based on E-9 (Air Force Chief Master Sergeant) BMC of $39,769
[4] Based on E-9 BMC of $39,769

Even the Civil Service system, which is also considered to be quite generous (and has been subject to the same types of criticism as the military pension (see [31]), requires that an individual have 30 years of service in order to retire at age 55 with full benefits.

Until Fiscal Year 1985, budgeting for military retirement was on a "pay-as-you-go" basis. Annual appropriations took into account payments to retirees and their survivors, but did not show the liability that the government had for future retirement payments for people who had not yet retired [11]. Leonard [32] estimated that this "hidden" cost amounted to almost $525 billion!

To provide a better indication of the cost of current and future liabilities of the retirement system, the government adopted an accrual accounting method beginning with the 1985 defense budget. This means that funds are set aside in current budgets to provide for the retirement annuities that will eventually be paid to service members. Specifically, the accrual charge is the "amount that must be set aside each year so that the discounted present value of the charges over the entire career of a group of military employees is equal to the discounted present value of retirement benefits that must be paid to those who remain in the service long enough to retire." [11].

An example from a 1983 Congressional Budget Office report shows the importance of this change in accounting: in 1983, the Administration proposed to add 180,000 people to the military over the next five years. Without accrual accounting, the added pension obligation for these individuals would not be evident until they started retiring in the year 2003. With accrual accounting, retirement costs in the 1983 budget would have gone up by about $1.2 billion - a 7% increase - making clear the government's future obligation.

Accrual accounting is more than a tool to accurately measure the budget effects of changes in manpower or in the pension system; it also provides another method of comparing costs of the military pension plan to the costs of other plans. The accrual charge used by the Department of Defense is about 35% of BMC (51% of basic pay). If the contributions of the government to a military member's Social Security benefits are taken into account, the figure rises to about 41% of BMC. In contrast, the civil service pension has an accrual cost of approximately 30% of salary, and estimates of the costs of "good" private sector plans are about 12% [14].

By many measures, then, the military pension is very generous. Personnel can retire when quite young with an immediate pension that is largely protected from the effects of inflation. The average retiree receives the pension for 35 years - longer than almost anyone is even allowed to serve [14]. It is certainly more generous in present value terms than civilian pension plans, and more generous than most other federal and state plans. It is also very expensive, both in terms of annual expenditures for current retirees and in terms of the accrual charges accounting for future retirees. Some have expressed doubt that the military pension system can be called a retirement plan at all - the Grace Commission stated that any retirement plan should have the purpose of providing security in old age, but the military pension plan was effectively a form of salary continuation.

With the generosity, expense, and perceived inequities of the military pension system, it may be surprising that the changes to it have been so limited. The reason for this is the military view that the pension serves purposes beyond those of civilian pension programs.

A Military Philosophy /Response

The Fifth Quadrennial Review of Military Compensation (QRMC V) lists six basic principles behind military compensation in general. Compensation should

1. be an integral part of overall force management
2. achieve economic and military efficiency

3. achieve equity
4. be effective in peace and war
5. be flexible enough to adjust to supply and demand
6. provide sufficient motivation for a "full" career.

As a part of the compensation system, the retirement plan must be:

a. structured to meet defense requirements. As such, it is "inextricably linked" to both the force management system and the other components of the compensation system.

b. supportive of service force management requirements. In particular, it must be structured as an incentive to each member to serve the maximum length career consistent with, and permissible by, service requirements

c. integrated into the Uniformed Services compensation system and structured to meet an income replacement function as well as an income maintenance function. ([17], vol 1, p. IV-2)

The tone of some of these principles indicates that as far as the military is concerned, the retirement plan is far more than a method of ensuring financial security in old age. Indeed, since under the Defense Officer Personnel Management Act of 1980 retirees are technically subject to recall to active duty at any time ([5], p.246), one could almost say that they are still, in a loose sense, on duty. The Supreme Court has effectively said as much: in its 1981 McCarty ruling, it stated that the pension was current earned pay at reduced rates for reduced services [35].

Several arguments are used to justify retaining the basic structure of the military retirement system. One of many "defense requirements" is for a "youthful and vigorous" force. With enlisted personnel entering the service at about 19 and officers at about 22, the vesting of the pension at 20 years encourages people to leave the service at the relatively young ages of 39 and 42, leaving behind younger members who now have the incentive to stay because of the possibility of promotion into the positions of those who retire ([14], p.13).

The QRMC V report also concludes that the retirement system meets the goal of encouraging members to serve the "maximum career consistent with service needs". It found that the military pension has a significant effect on retention for personnel between 8 and 12 years of service. Approximately 1/3 of the enlisted who reach the fifth year of service will serve through 20 years and receive retirement pay, and 2/3 of the officers ([17], Executive Summary, p.IV-29). Very few of either segment depart voluntarily after twelve years of service.

The QRMC V report argues that both officers and enlisted who leave the service go through a transition period of seven to nine years during which their salaries are significantly lower than their civilian peers. Since these retirees have been subjected to screening as they rose through the ranks during their military careers, the QRMC emphasizes that the retirees are clearly not average, and so the income loss upon retirement is even more of a burden. Making up for this difference should, it concludes, be a consideration in setting military compensation and the retirement pension.

Other studies have come up with conflicting estimates of the magnitude of the post-retirement earnings differential, and it is difficult to establish whether the difference is due to difficulty in becoming established in civilian positions or the result of voluntary acceptance of lower paying jobs because of the existence of the military pension. The post-retirement decrease in earnings argument for retaining the current retirement system may therefore be difficult to justify.

In discussing costs of the military retirement systems, supporters of the current system also emphasize the special nature of the military and the unusual demands placed on service members because of family separations, loss of individual freedom, and lack of control over living and working conditions. In testimony before the Zwick commission, the Secretary of the Air Force said:

> "Implicit in this concept of military service must be long-term security and a system of institutional supports for the serviceman and his family which are beyond the level of compensation commonly offered in the private, industrial sector". ([49], p. 176)

The pension is part of the compensation "beyond" civilian levels. Lieutenant General Benjamin O. Davis, responding to the recommendations of the Zwick Commission, notes that the special natu of military demands require that cost comparisons of retirement pay be made not with civilian pension plans, but with paramilitary organizations such as police departments, which also require a young and vigorous force and, in general, have quite generous retirement benefits ([49], p. 128).

Defenders of the current structure also claim that the rising costs of the retirement system are a function of changes in force management policies since WWII, the increased size of the uniformed services, and rising costs due to inflation. General David C. Jones, former Chief of Staff of the Air Force, called criticism of the cost of the system "the myth of spiraling retirement costs", and blamed increases on changes in the retiree population, rather han excessive generosity of the system. Larger military forces during WWII, the Korean Conflict, and Vietnam meant that there would be "bulges" in retirement later on. Changing the pension system to lower costs would be unfair, "victimizing" retirees because the government was unwilling to bear the costs of previous

The problem of determining force profiles and structuring compensation to support them is a more immediate problem in the case of the military pilot population, since shortages of pilots are already being experienced.

1.3 Incentive Pay for Pilots

The first authorization for extra pay to aviators was 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 ([5], p. 93.). According to Bartholomew, 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 compl ted their service obligation, and the incentive pay system was changed so that flight pay depended not only on grade, but on years of service. As was the case with the pay established in earlier acts, this flight pay was received only when the member was engaged in flying operations. As time passed, "excusal" policies were established which allowed receipt of flight pay even when the pilot was in a non-flying job.

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, 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. It had five basic provisions ([5], p.88):

1. Officers engaged in "frequent and regular performance of operational or proficiency flying duty" were entitled to continuous aviation career incentive pay regardless of whether or not they were actively flying at the time

2. ACIP rates were based on length of time served as a pilot, instead of on grade and length of time in the service (though after 18 total years of service there is an adjustment)

3. The highest ACIP rates were set for the years just after the end of a pilot's initial obligation, when many are tempted to leave.

4. ACIP was gradually phased out for senior officers

5. Flying time requirements ("gates") were established that determined how long ACIP would be received.

Table 1.4 shows the 1990 rates of incentive pay.

TABLE 1.4

AVIATION CAREER INCENTIVE PAY RATES

Years of Aviation Service[1]	Monthly Rate
2 or less	125
more than 2	156
more than 3	188
more than 4	206
more than 6	650
more than 18	585
more than 20	495
more than 22	385
more than 25[2]	250

[1]Includes time in flight training
[2]For 0-6 (Colonel) and below

Problems of Pilot Retention

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 ([19], p.103). The DoD Annual Report for 1989 echoes the concern that high pilot losses jeopardized combat readiness of the armed forces ([20], 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 ([18], p. 6-24). Figure 1.1 illustrates the anticipated shortages by years of service.

Figure 1.1 FY 94 Objectives and Inventory

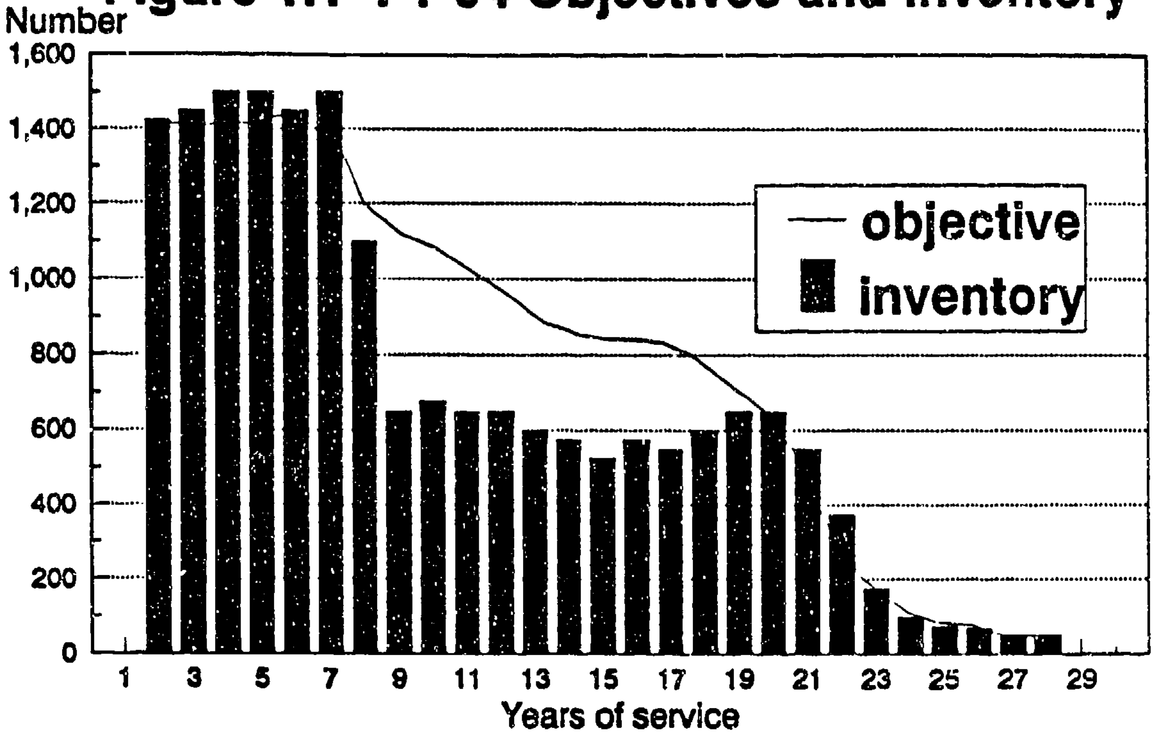
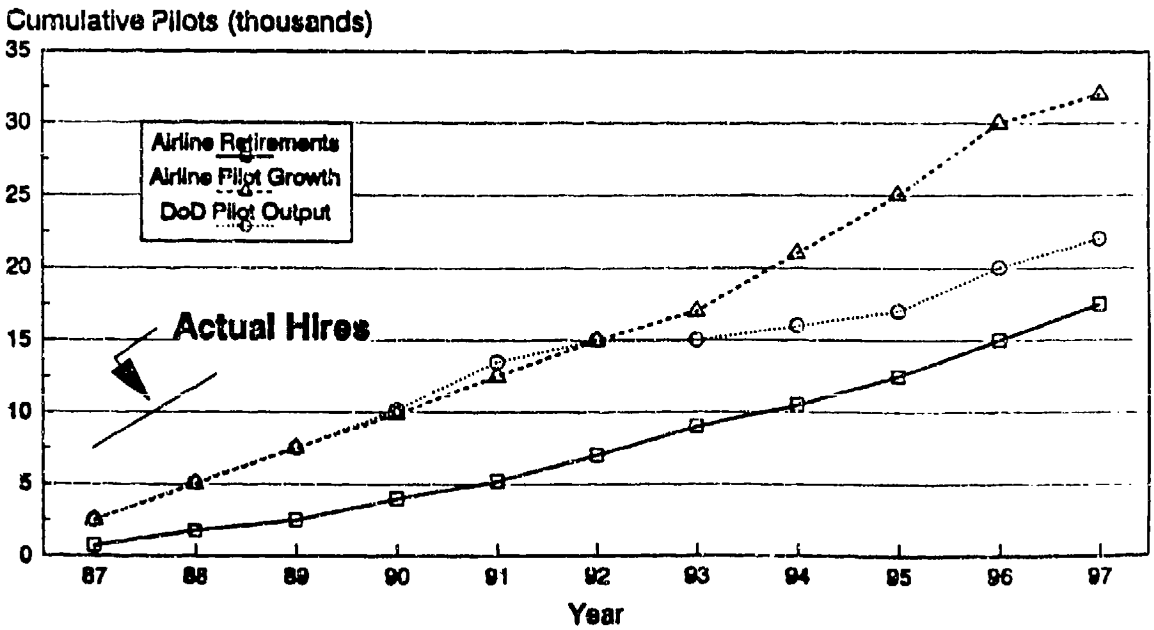


Figure 1.2 Projected Pilot Demand



Both figures redrawn from DoD Aviator Retention Study

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 ([18], p.2-5). Figure 1.2 shows projected hiring demand for large turbojet aircraft in the next ten years. It shows that all of the pilots produced by the military (excluding helicopter pilots) could be absorbed by the commercial airline industry. 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. In Table 1.5, salaries for five major airlines ($1 billion or more in annual revenue), average "national" airlines ($100 million to $1 billion in annual revenue, and average jet regional airlines ($100 million or less in annual revenue) are compared to three examples of military compensation.

TABLE 1.5

COMPARISON OF AIRLINE AND AIR FORCE INCOMES

Airline or Category	Second Year	Ten Year	Maximum (Captain)[1]
Delta	$31,000	$86,000	$167,000
Northwest	58,000	123,000	162,000
American	44,000	88,000	154,000
Federal Express	48,000	126,000	161,000
United	28,000	82,000	162,000
National Airlines	32,000	68,000	80,000
Jet Regionals	28,000	50,000	57,000
Air Force			
Capt, 8 yrs of service[2]:	45,420		
Major, 15 yrs of service[3]:		53,376	
Lt Col, 20 yrs of service[4]:			61,356

[1]With 1988 hiring rates, most pilots can expect to make captain within 5-10 years. Ten year rates in the table for Northwest and Federal Express are for captain's salaries; for other airlines they are first officer salaries.

[2]Married captain, pilot
[3]Married major, pilot
[4]Married Lt Colonel, pilot

NOTE: The military salaries are calculated with the 1989 pay table. VHA and tax advantage not included.
SOURCE: DoD Aviator Retention Study, pp2-11 and 2-12

Except in the case of the jet regional carriers, there is a clear, and large difference in potential earnings in favor of the airlines after the initial two year transition is completed. It should also be noted, though, that if an Air Force pilot leaves the service after completing an initial active duty service obligation (ADSO) of six years incurred upon completing flight training[6], he or she will be about 29 years old, and will be earning the large 10 year airline salaries by age 39, and possibly earlier. A major at 15 years of service is about 37, and a Lt Col retiring after 20 years about 42.

The decision to leave the military to seek an airline job is not always that easy, however. Even with the best paying airlines, military pilots will take a pay cut for the first few years (which can be compounded by the loss of certain money-saving privileges, such as lower prices at military commissaries), and it can take approximately five years until the airline salary makes up for the military compensation left behind ([18], p. 2-13).[7]

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." ([18], p. 2-8)

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[6]The Active Duty Service Obligation for pilot training has been increased three times since the 1970s. It was raised from 5 to 6 years in 1979, to 7 years in 1987, and to 8 years in 1988. Pilots able to leave the service in 1988 would be under the 6 year obligation.

[7]This is partly because of the existence of a so-called "two-tiered" pay system in some airlines that can result in pilots with the same levels of experience receiving different salaries because of the time they were hired. Some airlines have eliminated this structure, and according to the DoD study, some experts do not expect it to survive.

Proposed Solutions to the Pilot Retention Problem

In 1981, in response to pilot shortages in various aviation specialties, the Congress authorized Aviation Officer Continuation Pay (AOCP), which allowed annual bonuses of as much as $6,000 per year to pilots with between 6 and 12 years of service ([12], p.2). Only the Department of the Navy participated in the program, and it was terminated in 1982 because Congress felt that the bonus was an inappropriate method of dealing with the problem of pilot shortages ([5], p.90).

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 [8]. In 1989, the cost of this program from Fiscal Year 1990 through Fiscal Year 1994 was anticipated to be approximately $94 million.

Since the authorization of ACP, the Congressional Budget Office has studied at least five modifications of the bonus to address the anticipated Air Force pilot shortages through 1994. The cost of these plans ranges from $179 million to $492 million for the five year period 1990-1994.

1.4 Predicting the Effects of Changes in Compensation

I have noted that the Fifth Quadrennial Review of Military Compensation was highly critical of previous studies of changes in military compensation that did not consider the effects changes would have on force structure. The Review's plan of attack was first to "calibrate" DoD computer models to current retention rates, then to project new force profiles in response to changes in compensation policy using the Annualized Cost of Leaving Model discussed in the next chapter. From the new retention rates, recruitment and promotion policies were calculated that would be needed to sustain the force profiles, and a "life-cycle" cost of the whole system was determined ([17], vol I p. iv-10). The new force structure was compared to what was desired by the services, and in this way costs of changes and effects on the force were evaluated.

The first step in this process - predicting the effects changes in compensation will have on retention - is an extremely important one. The Quadrennial Review expressed "a high level of confidence in the ability of these models to correctly project the nature of the changes", but qualified that statement with, "however, the absolute values were and should be used with caution."

Unfortunately, when it comes to the effects of changes in the retirement system, it is impossible to test the validity of model predictions against observed changes in behavior, because none of the people affected by the changes made in 1980 or 1986 are near retirement yet. Those affected by the most radical adjustments to the system are, at least in the case of pilots, not even finished with their initial service obligations.

When considering compensation changes for pilots, predicting the retention effects of the changes is also important. While it is difficult to say what was used as the final basis for the decision to introduce ACP, there were at least four sources of information about predicted effects of the bonus available:

1. The observed effects of the AOCP on the Navy pilot population

2. A survey conducted by the Defense Manpower Data Center (DMDC) in September, 1988 with a sample of 3,648 Air Force, Navy, and Marine Corps pilots. A bonus (if set high enough) was the incentive to remain in the service ranked highest by the survey participants, and since another survey question set the maximum bonus at $12,000, the Department of Defense assumed that was the minimum required to improve retention ([18], p. 9-10).

3. A Computer Automated Telephone Interview (CATI) of 1600 Air Force pilots with 6-11 years of service conducted by the Air Force Military Personnel Center Surveys Branch in January 1988. The bonus options offered in this survey were slightly different than what were actually approved by Congress, but the CATI result was that 36% of those eligible would take the bonus [43].

4. Pentagon Air Staff econometric models (such as ACOL) that showed the costs of ACP outweighed by the savings in replacement costs for pilots because of improved retention.

Again unfortunately, it does not appear that the methods used by the Department of Defense worked very well in this case. The actual effect of the bonus plan was essentially nothing; in fact, retention rates for some pilot cohorts decreased [8]. In a follow-up survey of those who participated in the CATI, only 62% actually accepted the bonus. For those pilots with seven or eight years of service (a total of 398 in the sample), 80% had said they would take a bonus, but only 44% did.

This is not to say that the money spent on the bonus program was wasted. Because acceptance of the bonus carries with it a commitment to remain in the service through fourteen years, the Air Force has a better idea of what future replacement needs will be. Nonetheless, the effect of the bonus plan was much different than anticipated, and the decision to implement the bonus might have been different if models had predicted the effect more accurately.

Conclusion

Both the military pension system and bonus payments for pilots are expensive components of the military budget, but both are important in maintaining the force structure and readiness desired by the Department of Defense. The disappointing performance of the methods used to predict the behavior of pilots under the Aviation Continuation Pay bonus gives some cause to doubt their reliability in studying the effects of other changes in compensation - especially changes in the retirement pension.

To begin the search for a better predictor of the effects of compensation changes, the next chapter describes the mathematical details of alternative models of departure behavior.

CHAPTER TWO

MODELING DEPARTURE BEHAVIOR

2.1 Background

There have been at least two sources of motivation for the development of econometric models of job exit behavior. In the civilian sector, there has been a significant decline in the labor market participation of older workers for the past twenty years [47]. During the same period, private pension coverage has increased markedly, and social security benefits have risen. The study of any 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 be trying to induce certain employee behavior by changing the structure of their pension plans.

In the military sector, there is a slightly different problem. As Daula and Moffitt [15] point out, the armed forces must maintain adequate numbers of trained and experienced personnel without the possibility of lateral job entry. The absence of this remedy for loss of personnel means that shortfalls in any cohort are difficult to eliminate. To devise appropriate incentives to retain personnel, policy makers must be sensitive to the incentive effects of any proposed policy instruments, such as bonuses targeted for specific skill groups. "Policy makers cannot afford to rely on market feedback to iterate to an effective policy" say Daula and Moffitt [15], because, for example, a shortage of thirty-two year old military pilots with ten years of service cannot be eliminated by hiring such pilots from another military.

Both problems are important enough to have encouraged extensive research. Since 1983, The National Bureau of Economic Research has sponsored studies of the labor market aspects of pension plans as part of its study of the economics of aging. The military, through research at the Rand Corporation, the Center for Naval Analyses, and the Pentagon has been refining models for the behavior of officers and enlisted personnel since 1975. Indeed, Baldwin [4a] states that the economics of military manpower emerged as a branch of defense economics with the end of the draft.

Empirical and theoretical studies have shown that changes in compensation are often used by employers to effect adjustments in the workforce, and that employees have a general feel for the impact such changes will have on them. Zeckhauser and Nalebuff [37] claim that a major goal of pension plans is to induce people to retire, and the challenge for an employer is to design pensions that blend the competing objectives of attracting, sorting, motivating, and retaining workers with the need to encourage reasonable retirement choices. Bernheim [46] concluded that data in the Social Security Administration's Retirement History Survey showed that consumers correctly anticipated the general effects of changes in social security legislation in the 1970s. Viscusi [44] describes how, in the presence of uncertainty, pensions can be important in reducing the turnover of employees that are attracted to a firm. The military has frequently used special bonuses to encourage people to remain in the military, and one of the arguments against changes in the military pension is that it will lose its effect as an inducement to complete a twenty-year career.

Among the concerns of researchers studying the known and potential effects of changes in compensation, two are most important for the purposes of this dissertation. First, there is the form that the econometric model of behavior should have. Choices here can range from simple linear regressions with some measure of departure behavior as the dependent variable to very complicated dynamic programming schemes that tax the computational capacity of modern supercomputers. Part of this specification is the structure of any error terms that will be introduced in the model. Some sort of balance must be struck between the often conflicting needs of capturing "real" effects and retaining computational tractability.

A second concern is the availability of accurate data. One of the hindrances to early research in the effects of pension plans on the retirement decision was the difficulty of matching individuals with specific pension plan provisions.

Model Forms

Hausmann and Wise [25] have experimented with a "failure rate" or hazard model specification that is used in biomedical research in an effort to capture the qualitative choice framework (a person either retires or does not) as well as the continuous time nature of the problem. The empirical focus of their research with this model was the effect of health and social security payments on the retirement decision. Because they were dissatisfied with the lack of a natural utility maximization interpretation of the hazard model, they attempted another model that specifies disturbances as following a continuous time Brownian motion.[1] Estimation of the latter model was unsatisfactory.

Berkovic and Stern [6] and Rust [41] have both devised dynamic programming approaches to the problem, in both cases assuming that individuals have the objective of maximizing expected discounted utility over their remaining lifetimes when they make the decision to retire. Rust models retirement behavior as a "discrete control process" - a discrete time Markovian decision problem where the control variable is restricted to a finite set of alternatives. His formulation involves an error structure that requires integration over several dimensions in order to evaluate the value function for a decision, and "even with a very coarse grid approximation to the true continuous distribution [of the error term], the dimensionality of the resulting discrete approximation will generally be too large to be computationally tractable." Rust proposes a technique to make this problem easier, but the model is still difficult to implement.[2]

The Berkovic-Stern model is similar to the Daula-Moffitt model that will be discussed below, in which assumptions about the error structure make calculation of the value function much easier. What distinguished the work of Berkovic and Stern was the

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[1]Stock and Wise have shown in the appendix of [42b] that under very restrictive conditions, the hazard model does have a utility maximization interpretation.

[2]In a preliminary draft of newer work, "US Social Security Policy: A Dynamic Analysis of Incentives and Self-Selection", Phelan and Rust have adapted the model to address the effects of changes in Social Security amendments in 1983. Simplified examples in the paper involving 1803 individuals required 30 CPU minutes on a Sun IPC. They expect more realistic models to take about three hours on a CRAY Y-MP supercomputer.

inclusion of unobserved individual effects in the error structure, the use of continuous wage data in addition to discrete events (such as health status) and the method of simulated moments in the estimation technique.

Baldwin [4b] notes that most Department of Defense studies of retention behavior before the 1980s used aggregate time series or cross-sectional data. Army analysts shifted attention to models of individual behavior in the late 1970s, perhaps showing that military personnel were less homogeneous in their behavior. Baldwin and Daula [4a] list several estimation methods that have been used by the military. Enns [22] used least squares with the logarithm of the reenlistment rate as the dependent variable. Logit (especially the ACOL model discussed below), probit, and multinomial logit models have been the most popular approaches in other military studies. Gotz and McCall [23] and Daula and Moffitt have both developed dynamic programming models for military populations.

One problem of modeling retirement behavior that Lazear pointed out [30] is the use by many researchers of the value of a pension conditional upon retirement at a certain date. This, he says, is not the appropriate independent variable to use when trying to estimate the effect of pensions on retirement behavior, since its behavior is usually more discontinuous than the behavior it predicts. Instead, he recommended the use of what he called the option value of continued work - essentially the difference in value between retiring now and working until sometime in the future before retiring. This idea was part of the motivation for the Stock-Wise model that is the focus of this research. Military models, unusually ahead of their civilian counterparts, generally use an option value type approach.

Data

In addition to the already mentioned difficulty of matching individuals with specific pension plans, other problems facing researchers in retirement include no knowledge of sources of wealth outside income from work or pension, complications of the structure of social security benefits, and lack of information about behavior of an individual after leaving one firm (that is, did the individual actually retire or did he move on to new employment or to part-time employment). One of the important advantages of Stock and Wise in their work with the option value model is access to detailed information about pension plan participation and individual characteristics in a Fortune 500 firm.

Those who were involved in the development of models for retention behavior in the military had the same advantage Stock and Wise did. The pension plan available to military retirees is simple and the same for all members of the military who entered at the same time. Military pay is easy to determine, and so is eligibility for any bonus payments targeted to specific skill groups. In general, it is safe to assume that because of the relative youth of military personnel who retire, a new job is sought after leaving the service. Thus, some of the data problems in studying the incentive effects of alternative forms of compensation in the military are less difficult than for civilian firms -

although the prediction of potential civilian earnings after leaving the military does pose a problem.

This has been a brief overview of some of the issues related to the development of models of retirement behavior for civilians and the retention behavior of military personnel. This work compares the predictive power of three specific models, and the next sections will discuss them in detail. The option value section is based on Stock and Wise [42]. The discussion of the ACOL model is based on Warner [45], Argüden [2], and Gotz and McCall [23]. The dynamic programming section draws from Daula and Moffitt [15], Lumsdaine, Stock and Wise [33], and Gotz and McCall [23].

2.2 The Option Value Model

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

$$V_t(r)=\sum_{s=t}^{r-1}\beta^{s-t}U_M(s)+\sum_{s=r}^{T}\beta^{s-t}U_C(s) \quad (2.1)$$

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

$$V_t(t)=\sum_{s=t}^{T}\beta^{s-t}U_C(s)\,. \quad (2.2)$$

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

$$G_t(r)=E_tV_t(r)-E_tV_t(t)\,. \quad (2.3)$$

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.

Specification of the Utility Function

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

$$U_M(s)=Y_s^{\gamma}+\omega_s \quad (2.4)$$

$$U_C(s)=(C_s(r)+kB_s(r))^{\gamma}+\xi_s \tag{2.5}$$

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, probably more so than for people in civilian jobs, 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:

$$\omega_s=\rho\omega_{s-1}+\epsilon_{\omega s} \qquad E_{s-1}(\epsilon_{\omega s})=0\,, \tag{2.6}$$

$$\xi_s=\rho\xi_{s-1}+\epsilon_{\xi s} \qquad E_{s-1}(\epsilon_{\xi s})=0\,. \tag{2.7}$$

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

$$C_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} E_t(Y_s^\gamma + \omega_s) + \sum_{s=r}^{T} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma + \xi_s] \tag{2.8}$$

$$- \sum_{s=t}^{T} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma + \xi_s]$$

$$= \sum_{s=t}^{r-1} \beta^{s-t} E_t(Y_s^\gamma) - \sum_{s=t}^{r-1} \beta^{s-t} E_t[(C_s(r) + kB_s(r))^\gamma] \tag{2.9}$$

$$+ \sum_{s=t}^{r-1} \beta^{s-t} E_t(\omega_s - \xi_s)$$

$= g_t(r) + \phi_t(r).$

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

$$g_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} \pi(s|t) E_t(Y_s^\gamma) + \sum_{s=t}^{r-1} \beta^{s-t} \pi(s|t) E_t[(C_s(r) + kB_s(r))^\gamma] \tag{2.10}$$

and

$$\phi_t(r) = \sum_{s=t}^{r-1} \beta^{s-t} \pi(s|t) E_t(\omega_s - \xi_s) . \tag{2.11}$$

Under the Markov assumption for the individual specific errors, the expectation at time t can be written

$$E_t(\omega_s) = \rho^{s-t}\omega_t \qquad E_t(\xi_s) = \rho^{s-t}\xi_t \tag{2.12}$$

and so the function ϕ takes the form

$$\varphi_t(r) = \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\rho^{s-t}(\omega_t - \xi_t) \;=\; K_t(r)\nu_t \tag{2.13}$$

where

$$K_t(r) = \sum_{s=t}^{r-1} \beta^{s-t}\pi(s|t)\rho^{s-t} \qquad and \qquad \nu_t = \omega_t - \xi_t . \tag{2.14}$$

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." ([42a], p.11)
Finally, then, the expected gain in year t from postponing departure from the Air Force until year r is

$$G_t(r) = g_t(r) + K_t(r)\nu_t \quad . \tag{2.15}$$

Retirement Probability in a Single Year

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

$$Pr[R=t] = Pr[G_t(r) \leq 0] \quad \forall\ r \epsilon [t+1, t+2, \ldots, T]$$

$$= Pr[g_t(r) + K_t(r)\nu_t \leq 0]$$

$$= Pr\left[\frac{g_t(r)}{K_t(r)}\right] \leq -\nu_t \qquad \forall\ r \epsilon [t+1, \ldots, T] \tag{2.16}$$

This can also be written

$$Pr[R=t] = Pr\left[\frac{g_t(r*)}{K_t(r*)}\right] \leq -\nu_t \tag{2.17}$$

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

Retirement Probability in Multiple Years

If data are available for more than one year, we can follow the retirement decisions of individuals for each year. A person retires in year $\tau \in [t, t+1, \ldots, T]$ if there is no year before τ in which it is worthwhile to retire according to the above decision rule but it is worthwhile to retire in year τ. Thus,

$$Pr[R=r]=Pr\left[\frac{g_t(r*_t)}{K_t(r*_t)}>-\nu_t,\ldots,\frac{g_{r-1}(r*_{r-1})}{K_{r-1}(r*_{r-1})}>-\nu_{r-1},\ \frac{g_r(r*_r)}{K_r(r*_r)}\leq-\nu_r\right]. \qquad (2.18)$$

If the individual does not retire in the period under consideration, we have

$$Pr[R>T]=Pr\left[\frac{g_t(r*_t)}{K_t(r*_t)}>-\nu_t,\ldots,\frac{g_{T-1}(r*_{T-1})}{K_{T-1}(r*_{T-1})}>-\nu_{T-1},\ \frac{g_T(r*_T)}{K_T(r*_T)}>-\nu_T\right]. \qquad (2.19)$$

The problem of determining retirement is therefore a multinomial discrete choice problem with dependent error terms ν.

In order to estimate the parameters of the model, an additional assumption about the distribution of the errors is necessary. Following Stock and Wise, assume that the ν_s terms follow a Gaussian Markov process

$$\nu_s=\rho\nu_{s-1}+\epsilon_s \qquad \epsilon_s \ \ IID \ \ N(0,\sigma_\epsilon^2) \qquad (2.20)$$

where the initial value ν_t is IID normal with mean 0 and variance σ_t^2 and is independent of ϵ_s for s = t+1,...,T.

The covariance between time periods and the variance of the error term in a given period are ([28], p. 301)

$$cov(\nu_r,\nu_{r-1})=\rho\, var(\nu_r), \qquad var(\nu_r)=\rho^{2(r-t)}\sigma_t^2 + \sum_{j=0}^{r-t-1}\rho^{2j}\sigma_\epsilon^2 \qquad (2.21)$$

Under the assumption that the errors follow a random walk, these are

$$cov(\nu_{\tau},\nu_{\tau+1})=var(\nu_{\tau}), \qquad var(\nu_{\tau})=\sigma_{\nu}^{2}+(\tau-t)\sigma_{\epsilon}^{2}\,. \tag{2.22}$$

Stock and Wise point out that there are two ways of viewing the reduced uncertainty of the departure decision as the "planning horizon" shortens. First, there are fewer random components to cumulate in the term $K_t(r)$. Second, the uncertainty of the value of future random effects is reduced because the Markov assumption yields a decreasing variance of ν_t as the planning horizon is shortened. For civilians, this can be viewed as capturing the property that in a given calendar year the uncertainty about the retirement decision is greater for younger employees than for older ones. In the military case, the difference in the random components cumulated for younger and older officers appears to allow the model to capture differences in the characteristics of the populations at different stages in their careers.

Retirement Conditional on Being in the Sample

Stock and Wise note that to be strictly correct, the retirement probabilities of equations 2.17 and 2.18 can be used only if the individual first considers retirement in year t. If this is not true, the probability to be calculated should be the conditional probability

$$Pr[R=t\,|\,R>t-1]=\frac{Pr[R=t]}{Pr[R>t-1]}\,. \tag{2.23}$$

If t_0 is the year a person first considers retirement, the numerator of this expression is given by

$$Pr\left[\frac{g_{t0}(r^*_{t0})}{K_{t0}(r^*_{t0})} > -\nu_{t0}, \ldots, \frac{g_t(r^*_t)}{K_t(r^*_t)} \le -\nu_t\right]$$

and the denominator is

$$Pr\left[\frac{g_{t0}(r^*_{t0})}{K_{t0}(r^*_{t0})} > -\nu_{t0}, \ldots, \frac{g_{t-1}(r^*_{t-1})}{K_{t-1}(r^*_{t-1})} > -\nu_{t-1}\right].$$

Estimating this conditional probability requires choosing a time t_0 when the individual first considers separation from the service. For Air Force pilots, this can be considered the first year after the completion of the initial service obligation incurred because of pilot training. While this presents little difficulty for those in the early stages of their careers, evaluation of the conditional probability requires a 22-dimensional integral for those considering departing the military after 28 years of service. Stock and Wise refer to their parameter estimates, based on the unconditioned equations, as quasi-maximum likelihood estimates.

In their dynamic programming discussed below, Gotz and McCall used the conditional probability expression with retirement data over a six year period, but only worked with Air Force officers through 13 years of service.

2.3 The Annualized Cost of Leaving Model

The most popular of the Department of Defense retention behavior models is called the Annualized Cost of Leaving (ACOL) model, and was developed by John T.

Warner in [45]. The ACOL model 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 computer program called the "Compensation Model" for determining the effects of various changes in compensation policies [38]. The Department of Defense Aviator Retention Study [18] and the Congressional Budget Office [12] also relied on the model, either directly or indirectly, to predict the effects of the 1989 pilot bonus program.

As formulated by Warner, the ACOL model attempts to account for differences in individual tastes for the military way of life and assign a dollar value to that taste. This leads to some inconsistency in the interpretation of the model, as we will see.

We assume that individuals are risk neutral, that military compensation and pension benefits are valued the same (the k in the option value model is 1), that future forms of compensation are known with certainty (ie, there is no random component to utility) and that an individual has a taste Γ for the military. In year s, the utilities associated with Air Force work and with a civilian employment are then

$$U_M(s)=Y_s+\Gamma \qquad and \qquad U_C(s)=C_s(r)+B_s(r)\,. \tag{2.24}$$

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

$$V_t(r)=\sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)(Y_s+\Gamma) \quad +\sum_{s=r}^{T}\beta^{s-t}\pi(s|t)(C_s(r)+B_s(r)) \tag{2.25}$$

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

$$V_t(t)=\sum_{s=t}^{T}\beta^{s-t}\pi(s|t)(C_s(r)+B_s(r)) \tag{2.26}$$

In year t, the total "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, and has the same form as the function $G_t(r)$ in the option value model (equation 2.3) with the taste term added:

$COL_t(r) = V_t(r) - V_t(t) =$

$$\sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)Y_s + \sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)(C_s(r)+B_s(r)) + \Gamma\sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t) \tag{2.27}$$

We can put this cost in terms of the amount foregone each year if an individual leaves in year t instead of in year r by writing

$$COL^*_t(r) = ACOL_t(r) + \Gamma, \tag{2.28}$$

where

$ACOL_t(r) =$

$$\left[\sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)\right]^{-1}\left[\sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)Y_s + \sum_{s=t}^{r-1}\beta^{s-t}\pi(s|t)(C_s(r)+B_s(r))\right] + \Gamma. \tag{2.29}$$

In terms of components used in the option value model framework, this can be written

$COL^*_t(r) = g_t(r)/K_t(r) + \Gamma$

when ρ is equal to one.

To see how this model works in determining the behavior of a group of individuals, suppose that each member of the group has the same current and future income potential, and that members differ only in their tastes for the military. An officer will stay in the service if the total cost of leaving is greater than zero, and leave if the total cost of leaving is less than or equal to zero. Since all of the individuals in the group are assumed to have the same income potential, the determining factor in a decision will be the individual's taste. For each individual, there is some year r that has the highest total cost of leaving, and this is the year that has the highest $ACOL_t(r)$ value. Again, for all of the individuals in the group under consideration, this value will be the same and will result from leaving the military in the same year. Designate this maximum value by

$$ACOL^* = \max_r ACOL_t(r).$$

For this group of officers, those who are indifferent to staying or leaving are those for whom $ACOL^* + \Gamma = 0$, or

$$\Gamma^* = -ACOL^*.$$

Those with greater taste for the military will remain; those with less taste will depart.

If we assume that the tastes of the group are distributed logistically, the retention rate for the group will be

$$\int_{-ACOL*}^{\infty} f(\Gamma)d\Gamma = \int_{-\infty}^{ACOL*} f(\Gamma)d\Gamma = F(ACOL*) \quad (2.30)$$

where f is the density function and F the cumulative distribution function for the logistic distribution. This retention pattern is shown graphically in Figure 2.1.

So far, this discussion has assumed that the tastes of individuals persist over time. In practice, the parameters of the taste distribution are estimated in the usual logit binomial choice framework, where we assume there is an underlying choice variable

$$y^* = \alpha_0 + \alpha_1 \text{ ACOL}^* + \epsilon \quad (2.31)$$

that is not observed, but a person remains in the military if $y^* > 0$ and leaves if $y^* <= 0$.[3] The error term ϵ is to account for any unknown monetary or non-monetary factors (including taste for the military) that would affect the decision to leave. If the error term is assumed to have a logistic distribution, the probability of remaining in the military (the retention rate) is

$$\Pr[y^* > 0] = \Pr[\epsilon > -(\alpha_0 + \alpha_1 \text{ACOL}^*)]$$

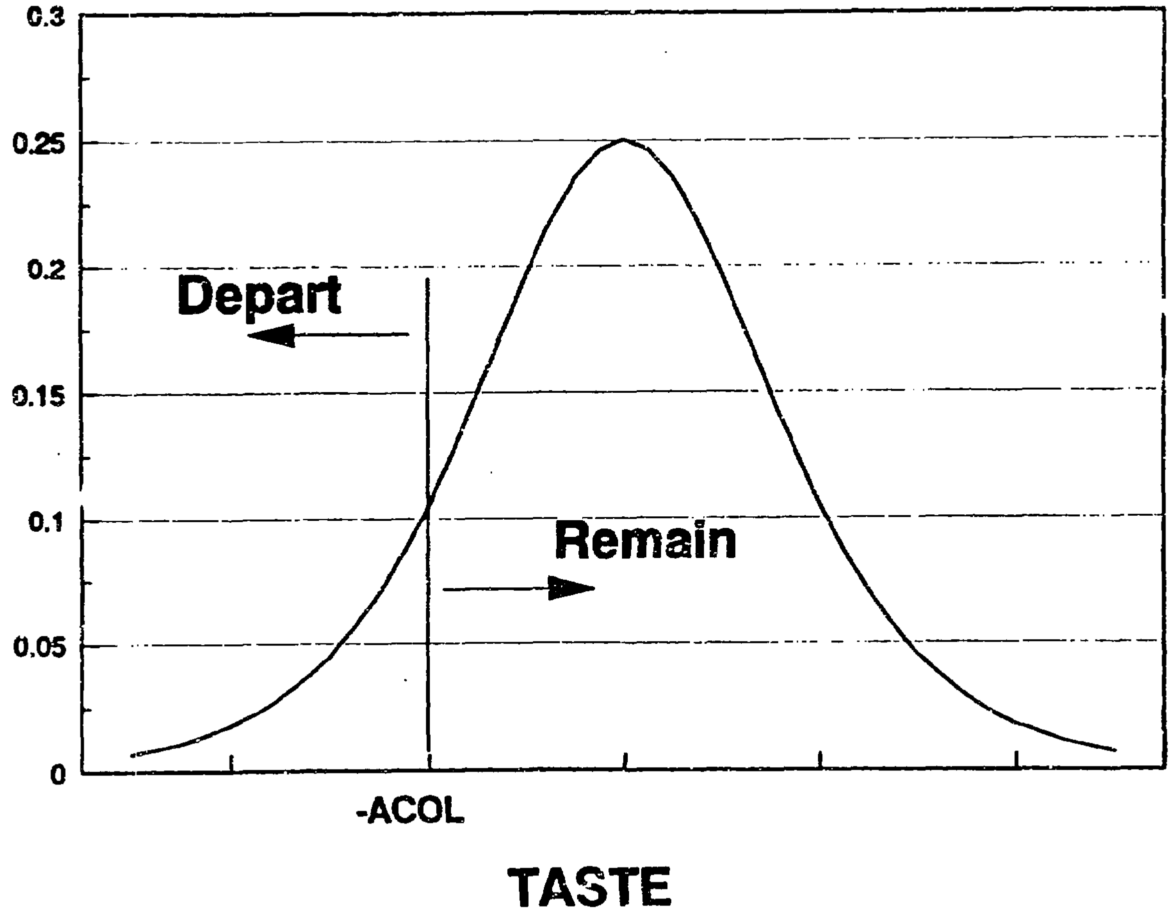
$$= \left[1 + e^{-(\alpha_0 + \alpha_1 ACOL^*)}\right]^{-1} \quad (2.32)$$

Gotz and McCall point out the inconsistency in the interpretation of the ACOL model and the estimation procedure used: the taste interpretation implicitly assumes that

[3]This is similar to a probit specification used by Lumsdaine, Stock and Wise in [33].

FIGURE 2.1

Logistic Taste Distribution



the tastes for the military persist over time, while the logit estimation procedure assumes that the error terms (which include the taste for military life) are identically and independently distributed over time.

Problems with the ACOL Model

Argüden [2] points out some of the inadequacies of the ACOL model. First, it cannot deal with the effects of censoring because of self-selection. We expect that over time those who have lower taste for the military style of life will leave, and so the mean taste of individuals in a group with the same number of years of service will increase as time passes, and the standard deviation of the taste distribution will decrease. The parameter α_0 in the ACOL estimation is proportional to the mean of the taste distribution, and the coefficient α_1 is proportional to the inverse of the standard deviation. Thus, if these parameters are estimated for a group with a wide range of years of service, the α_1 coefficient will be too large for those with lower years of service (where the standard deviation in tastes is large) and too small for those with higher tenure (where the standard deviation in tastes is small).

On the other hand, since the ACOL model does not explicitly model random shocks experienced by individuals, its estimate of the variance of tastes "incorporates some of the variance of the random shocks" ([2], p. 80) and typically overestimates the variance of the taste distribution. The net effect of the two biases is that the α_1 coefficient is too small, and the effects of changes in compensation will be underestimated.

Argüden also expresses concern that because of the choice of the relevant ACOL* value in the model, it will not predict retention effects for compensation changes that do not affect the value or the time when ACOL* is reached. He feels that because of this, the effects of policy changes that, for example, change when an individual is vested in the military pension but keep the total present value of benefits received the same, will be overestimated.

2.4 Dynamic Programming Approaches

In 1984, Gotz and McCall [23] developed a dynamic programming model of retention behavior for Air Force officers. Later, Daula and Moffitt [15] devised a model slightly different in structure, and less complicated in implementation, for Army enlisted retention behavior. The dynamic programming model presented here is the Daula-Moffitt model allowing for a parametrized utility function and the introduction of an individual-specific random effect.[4] When estimating retirement in one period, the Gotz-McCall model reduces to the model of Daula and Moffitt.

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 model, the decision is based on the expected value of the

[4]As modified in [23]. References to the Daula/Moffitt model hereafter will be to the modified version.

maximum of current versus future options. A brief 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.

The Model of Daula and Moffitt

Assume an individual's utility from Air Force employment in year s is

$$U_M(s) = Y_s^\gamma + \Gamma + \epsilon_{1s} \quad (2.33)$$

and utility from leaving for a new job is

$$U_C(s) = [C_s(r) + kB_s(r)]^\gamma + \epsilon_{2s}. \quad (2.34)$$

The term Γ is a random additive taste for work, and is assumed to be distributed as $N(0,\lambda^2)$. If $\lambda=0$ as we will assume in some estimations, there is no 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. Future income and retirement benefits are assumed to be non-random.

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

$$W_t = \max\left[E_t(Y_t^\gamma + \Gamma + \epsilon_{1t} + \beta W_{t+1}),\ E_t\left(\sum_{s=t}^{T} \beta^{s-t}(C_s(t) + kB_s(t))^\gamma + \epsilon_{2t}\right)\right] \quad (2.35)$$

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

$$W_t = \max\left[W^*_{1t}+\epsilon_{1t}, W^*_{2t}+\epsilon_{2t}\right], \tag{2.36}$$

where

$$W^*_{1t} = Y_t^\gamma + \Gamma + \beta\pi(t+1 \mid t)E_t W_{t+1} \tag{2.37}$$

and

$$W^*_{2t} = \sum_{s=t}^{T} \beta^{s-t}\pi(s \mid t)(C_s(t)+kB_s(t))^\gamma \tag{2.38}$$

An individual will decide to leave the military if

$$W^*_{1t}+\epsilon_{1t} < W^*_{2t}+\epsilon_{2t}, \tag{2.39}$$

and so the probability of leaving in year t is

$$Pr[W^*_{1t}+\epsilon_{1t} < W^*_{2t}+\epsilon_{2t}] = Pr[\epsilon_{1t}-\epsilon_{2t} < W^*_{2t}-W^*_{1t}]\,. \tag{2.40}$$

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 2.40 as

$$Pr[R=t] = Pr\left[\frac{(\epsilon_{1t}-\epsilon_{2t})}{\sqrt{2}\,\sigma} < \frac{(W^*_{2t}-W^*_{1t})}{\sqrt{2}\,\sigma}\right] = \Phi(a_t) \tag{2.41}$$

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_{it} that is $E_{t-1}W_t$. In Appendix 1, we show that this is

$$E_{t-1}\left[\frac{W_t}{\sigma}\right] = \frac{W*_{1t}}{\sigma}(1-\Phi(a_t)) + \frac{W*_{2t}}{\sigma}\Phi(a_t) + \sqrt{2}\,\phi(a_t) \tag{2.42}$$

where ϕ is the standard normal density function.

In equation 2.42, $\Phi(a_t)$ 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 2.42 to recursively calculate the values of $W*_{1t}$ and $W*_{2t}$, and then use equation 2.41 to calculate the probability of retirement.[5]

The Dynamic Retention Model of Gotz and McCall

Gotz and McCall [23] developed a "rich" dynamic programming model, called the Dynamic Retention Model (DRM) in 1984. The structure of the decision rule is

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[5]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. On a 486/25 PC, the calculation time for a table of departure rates for 1194 individuals more than doubled, from about three minutes to over seven.

essentially the same as that used by Daula and Moffitt, except there is no random component to utility from leaving the military. As a result, the recursion relationship becomes[6]

$$E_{t-1}\frac{W_t}{\sigma}=(1-\Phi(a_t))\frac{W*_{1t}}{\sigma} + \Phi(a_t)\frac{W*_{2t}}{\sigma}+\phi(a_t) \tag{2.43}$$

where $a_t = (W^*_{2t} - W^*_{1t})/\sigma$, which is similar to equation 2.42 (without the square root of 2), and the probability of departing the service is again

$$Pr[R=t]=\Phi(a_t)\,. \tag{2.44}$$

Gotz and McCall hoped to allow for changes in some Air Force personnel policies in their model. To do this, they did two things. First, they formed a list of 54 mutually exclusive Air Force "states", location in which is determined by grade (rank), year of service promoted to that rank, and the component of service.[7] Movement among the states is assumed to be generated by a first order Markov chain with transition probabilities P_{ijt} $i= 1,\ldots,53$; $j=1,\ldots,54$; (state 54 is the transition to civilian life) $t=4,\ldots,30$ - the probability of moving from the rank and component represented by i to that represented by j in year t. This structure is used when calculating expected military pay, and allows the researcher to incorporate changes in promotion rates if desired.

[6]As in the original Daula/Moffitt model, utility is equal to income in the Gotz/McCall model, and there is no k factor to modify the valuation of pension income.

[7]That is, whether the officer holds a regular or a reserve commission. Reserve officers on active duty have different promotion rates and tenure limitations than regular officers.

Second, they developed a relationship between the taste distribution of officers with regular commissions and those with reserve commissions. Assuming that there is a positive correlation between an individual's taste for the military and his or her performance, and that in observing the increased performance of those with higher taste the Air Force is more inclined to offer regular commissions, the underlying taste distribution of those with regular commissions will be different from the mixture of tastes of those who do not receive regular commissions. Air Force policy affects the difference between the taste distributions of the two groups when it determines the percentage of reserve officers who will be selected for regular commissions. Gotz and McCall capture this effect with what they call a "selectivity" parameter.

As noted earlier, unlike Stock and Wise, Gotz and McCall used the more correct conditional probability equation when they estimated parameters for retention. However, they limited their attention (partly because of data limitations) to a five-year sample period, and conditioned on the year when an officer's initial service obligation expired. Thus, the highest dimension of integration required was five, but their analysis included officers only through a maximum of 13 years of service. Even so, the complication introduced by estimating the taste factor meant that their estimation was time consuming and did not allow inexpensive estimates of asymptotic standard errors (which are not reported in their paper).

2.5 Summary and Remarks

We have reviewed four models of an individual's decision to leave the military. All of them share the basic notion that an individual compares the potential benefits of leaving now with those of remaining until some time in the future. The differences are in how the comparison is made, and it will be useful to summarize these differences in order of increasing computational complexity of the models to highlight the advantages and limitations of the approaches to determining behavior.

The ACOL model, the simplest, makes the most assumptions: individuals are risk neutral, pension benefits and non-pension income are valued the same, future income streams from military and non-military sources are known with certainty. In practice, the individual discount rate is never estimated.[8] As Daula and Moffitt emphasize, this can be an important limitation, since the effect of compensation changes such as pension adjustments will be dependent on discount rates. "Without an empirically validated estimate of this parameter, the model would only be useful as a simulation tool and could not be viewed as a source of reliable predictions of the ultimate effect of this type of compensation change." ([15], p. 3)

With the above assumptions, plus the assumption that $\rho=1$, the term $g_t(r)/K_t(r)$ of equation 2.3 in the Option Value model is the same as the ACOL* value of the ACOL model. However, the logit estimation of the ACOL model results in the biases mentioned in the previous discussion, because the procedure effectively determines the

[8]The value of r is frequently assumed to be .1 ($\beta=1/(1+r)=.91$). Some of the work done for the Fifth Quadrennial Review of Military Compensation calculated ACOL values using discount rates that varied with an individual's years of service.

mean and standard deviation of the military "taste" of the aggregate population under investigation, instead of the taste distributions of each years-of-service cohort, and so suffers from censoring problems.

The option value model and the dynamic programming model are similar in spirit (Wise has called the option value model a "poor man's" dynamic programming procedure), with the theoretical difference being the use of the maximum of the expected value of future utilities in the option value model and the use of the expected value of the maximum of future versus current utility options in the dynamic programming case. The expected value of the maximum of a sequence of random variables is larger than the maximum of the expected values. If this difference is large, the dynamic programming approach will assign higher values to the decision to remain in the military than the option value model does. If the option value model is closer to the decision process that an officer actually undertakes, the dynamic programming model may predict lower departure rates than are observed because of the higher value placed on remaining in the military.

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" ([33], p. 14) in the dynamic programming model.

The introduction of the taste component in the dynamic programming model substantially increases the computation time when estimating the parameters of the model.

The model of Gotz and McCall has the computational burden of dealing with a taste factor and the conditional probability formulae for retirement rates, but also has two different assumptions. Individual discount rates are, as in most applications of the ACOL model, assumed to be .91, and individuals are assumed to be risk neutral. Though this eliminates the determination of two parameters important in the option value model, Gotz and McCall replace them with two others. Instead of assuming that the distribution of tastes has a zero mean, they estimate a mean - apparently to compare to taste values found in applications of the ACOL model. In addition, they determine the "selectivity" parameter that relates the taste distributions of reserve officers to that of regular officers.

Argüden has used the Dynamic Retention Model in [2] and [3] to study the limitations of simpler models, but his work highlights the difficulty of estimating the parameters of the model. In working with retention behavior for enlisted personnel, Argüden developed what he called a "calibrated" DRM - determining plausible parameter estimates that fit retention rates for the years he was studying instead of formally estimating them. Under the assumption that the DRM was a better representation of actual enlistee behavior, he then compared the predicted effects of compensation changes to those predicted by simpler models such as the ACOL model.

Conclusion

A policy analyst thus has a range of options to consider in studying the effects of changes in compensation: the ACOL model can be used with speed but with known and, especially in the case of pension changes, important biases. The Dynamic Retention Model can be estimated, but with great difficulty, especially if conditional probability formulas are used in determining retention patterns of officers with more than thirteen years of service and a "taste" factor is introduced. In between these two extremes are the option value model and the simpler dynamic programming model of Daula and Moffitt.

The tradeoffs between the accuracy of predicting behavioral patterns and the ease of calculation has been addressed by Lumsdaine, Stock and Wise [33] in the case of a civilian firm, and they found that the option value model and the dynamic programming model produced similar results, with both doing substantially better in predicting the effects of pension changes than various forms of a probit model (similar to the ACOL model).

To see if this holds true for a military population, we will in the next chapter estimate the parameters of the option value, Daula-Moffitt, and ACOL models for the departure patterns of a group of Air Force pilots in 1988, before the introduction of Aviator Continuation Pay.

CHAPTER THREE

ESTIMATION

This chapter describes the sample, method of estimation, and departure rate predictions used in comparing the option value, dynamic programming, and ACOL models.

3.1 Sample Description

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 departure patterns for those with prior service are quite different from those of officers without prior service.

The file lists the Air Force Command to which the pilot belongs, and the model estimates in this chapter 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 aircraft.

Officers in the file are recorded as being present or not present in the Air Force when the file is updated annually. 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 civilian pay for the full year 1989.

Military Income

In other work with military populations, researchers have used two approaches to predicting future income. The first involves using military pay tables and making assumptions about real growth in military income to determine the pay for a given combination of rank and years of service in future years. For example, Argüden [2] used 1981 pay tables for all income calculations in his work, assuming that nominal increases in military wages would match inflation. Using these predicted pay tables, future income for an individual is determined by the probability that he or she will be in a certain rank after serving a given number of years, where the probability of promotion is based on historical promotion rates. Gotz and McCall used this approach, as we saw in Chapter Two, and Hogan and Goon [26] considered it.

Hogan and Goon also estimated future compensation with a least squares regression, using the logarithm of regular military compensation as the dependent variable and race, gender, years of education, years of commissioned service, weapon system (eg, type of aircraft flown), and cohort entry year as independent variables. These predictions were then adjusted for real growth each fiscal year, based on increases in pay and allowances.

Hogan and Goon found that the method of predicting future compensation had no significant effect on the estimates of key parameters in their work with the ACOL model.

Military pay increases in a given rank occur regularly at two-year intervals between three and twenty-two years of service, and opportunities for promotion occur at generally predictable times in an individual's career. This regularity, and Hogan and Goon's observation that there seemed to be no advantage in basing predictions on forecast promotion rates using pay tables, led me to follow Stock and Wise in estimating future income with a second order autoregression:

$$\Delta \ln Y_t = a_1 S_t + a_2 S_t^2 + a_3 \Delta \ln Y_{t-1} + a_4 \Delta \ln Y_{t-2} + a_5 S_t \Delta \ln Y_{t-1} + a_6 S_t \Delta \ln Y_{t-2} + e_t \quad . \qquad (3.1)$$

where Y_t is the income in year t, S_t is the years of service in year t, and e_t is an error term. This equation captures the pattern of military pay increases in two ways. First, the number of years of service enters as a determinant of pay. Second, since different promotion histories will be evident in different pay histories, pilots who differ only in their past promotion rates will have different predictions of future income.

The information in the cohort file included rank, year of commissioning, and whether or not an individual had dependents. With this, pay tables from 1974 to 1990 were used to construct known compensation for pilots in the sample. These values were converted to 1986 dollars using the Consumer Price Index for urban consumers from the CITIBASE data set. The autoregression equation was then estimated using 56,351 observations (including multiple observations for each individual) for the 1974 - 1990 period. The equation was estimated for both Basic Military Compensation and Regular Military Compensation; coefficient estimates are shown in Appendix 2.

For the option value model, the expected value of future utility also must be calculated. This is approximated using a second order Taylor series expansion around the mean of a stream of earnings for an individual as shown in Appendix 2. For the other models, this calculation was not necessary.

Civilian Income

Hogan and Goon used three sources of data on civilian incomes in their estimations of the ACOL model. The first was pay data from the Air Line Pilots Association (ALPA), from which Hogan and Goon estimated a very simple regression of the logarithm of earnings on civilian airline experience and experience squared. This is consistent with the general observation that regardless of previous experience, airline pilots start out at the same level of pay. The equation shows a rapid rise in pay with experience, which is also consistent with the high airline salaries noted in Chapter One.

The second source was micro data of individual earnings from the Current Population Survey (CPS) of May 1979. The earnings of 20,000 civilians were estimated as a function of experience, race, gender, education level, and academic degree. When estimating pilot incomes, Hogan and Goon assumed that all pilots had degrees in an engineering discipline.

The third source was a Post-Service Earnings History File, created by the Internal Revenue Service, the Social Security Administration, and the Defense Manpower Data

Center. It contains civilian earnings from 1979 to 1983 for officers who left the military between Fiscal Year 1972 and Fiscal Year 1980.

Hogan and Goon felt that the Post-Service Earnings History File had the major weakness of recording earnings only of officers who had left the service, and who may have significantly different earnings opportunities than those who remain in the Air Force. They note that if those who leave do so because of very high civilian offers, the estimated earnings equation would overstate the potential earnings of the typical officer. On the other hand, if many of those in the file left after becoming eligible for the military pension, they might be satisfied with lower paying civilian jobs, and the estimated earnings equation could understate potential earnings for the typical officer.

When comparing the three sources, Hogan and Goon found that the CPS and ALPA data produced similar results in ACOL estimations, and both were superior in statistical measures (more precise coefficient estimates and better likelihood function values) to estimations using the Post-Service Earnings History File. Because the estimates using the CPS data were slightly better than the ALPA estimates and were also closer to values obtained in previous work, Hogan and Goon used the ACOL parameters from the CPS estimation as the basis for their analysis.

For this sample, estimates using CPS and ALPA civilian income predictions were also very similar, but the ALPA income estimates allowed a better fit of observed departure behavior.

Pension Calculation

Except for the small number of individuals in the sample who had completed only six years of service in 1987, all pilots were under the pension plan that existed for those commissioned before September 1980. All pensions were calculated using this formula.

Social Security Benefits

Social Security benefits were calculated using the formulae in the 1990 edition of Social Security Explained [10]. Benefits were based on basic military pay, plus noncontributory wage credits that are imputed to service members as described in that volume. Benefit calculations require knowledge of a person's entire earnings history, so the income of officers who joined the Air Force before 1974 had to be estimated. This was done by assuming that individuals were promoted at "average" rates after commissioning, achieving the rank of first lieutenant after two years of service, captain after four, major after eleven, and lieutenant colonel after sixteen. Basic pay was calculated using pay tables based on these ranks for the appropriate calendar year. Since social security benefits depend only on basic pay, no assumptions were necessary for BAQ, VHA, or incentive pays.

When calculating post-Air Force benefits, individuals were assumed to work for a civilian airline until age 62[1]. It was also assumed that they elect to receive social security benefits at age 62.

[1]Currently, Civilian pilots are required to retire at age 60, but unions are lobbying to have the limit eliminated, and it is likely the effort will be successful.

Each year, the government specifies a limit to the amount of earnings that can be considered to calculate the social security benefit; in addition, the benefit itself is based on average earnings in the United States two years before an individual's retirement. In order to estimate future social security payments, a growth rate for these two values must be assumed. To be consistent with the work of Stock and Wise, the growth rate was assumed to be 7.5% per year.

Finally, since social security and pension benefits are based on nominal incomes, CPI values were needed after 1990 to convert values to 1986 dollars. Again following Stock and Wise, these were calculated with the assumption that inflation was 6% per year.

3.2 Option Value Model Results

The data set included a code in each year that indicated whether an individual had an Active Duty Service Commitment Date (ADSCD), which means that the person had incurred some sort of military obligation that precluded leaving the service. The option value, dynamic programming, and ACOL models were used to predict the departure rates of those pilots in the sample who did not have such an obligation. The Air Force refers to this rate as the Voluntary Loss Rate.

A limitation of the data set used here is that the reason for an individual's departure is not noted, and so some of those recorded as leaving the military may have done so involuntarily. This is not a significant problem before 20 years of service are completed, because involuntary departure rates before then are below 0.6% for most cohorts. Where it might introduce difficulties is in cases where officers who have not been promoted are reaching the maximum tenure allowed for their rank. In this sample, for example, there are 30 officers in the rank of major who in 1987 had served for 19 years without promotion to lieutenant colonel, which generally means that the Air Force can force them to retire. In 1988, fourteen o. these majors remained (one of them having been promoted), and it is likely that some of those who left did so involuntarily. However, I elected not to eliminate officers such as these from the sample because the continued service of the fourteen indicates that at least some of them have a choice in whether or not to depart. Their presence in the sample will not affect the comparison of the predictive accuracy of the three models.

Single Year Estimation

Table 3.1 lists quasi-maximum likelihood estimates for the single year option value model. The first set of parameters fixes γ at one; the second estimates it. In both cases, the errors are assumed to develop as a random walk, with ρ fixed at one.

TABLE 3.1

OPTION VALUE MODEL[2]

Parameter Estimates Based on Voluntary Loss Rates in One Year
19[illegible]

	γ	k	β	σ (x 10^5)	$-\mathcal{L}$
1.	1*	3.32	.948	.893	505.90
		(.032)	(.005)	(.012)	
2.	1.82	3.28	.896	.754	496.45
	(.056)	(.020)	(.006)	(.027)	

*Parameter value fixed
Numbers in parentheses are asymptotic standard errors
ρ is fixed at 1
Sample size is 1803 (1194 had no commitment to remain)
$\mathcal{L}$ is the value of the log likelihood function

Parameter Interpretation

The size of some of the parameters in Table 3.1 deserves comment. The γ estimate for the option value model is very high - more than twice the values found by Stock and Wise in their work with a Fortune 500 firm, and statistically significantly larger than one. The estimates for k are also larger than those found with option value models of the civilian firm, though they are only slightly higher than k values Lumsdaine, Stock and Wise [33] found using the dynamic programming model.

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[2]Parameters in this and the following tables were calculated using a variation of the Davidon-Fletcher-Powell quadratic search method in a Gauss software routine and a "modified simulated annealing" random search algorithm written by Jim Stock. The latter method helps guarantee that maxima are global.

I have found no other work with military populations that attempts to estimate a risk aversion parameter, which is what a literal interpretation of γ would be. Gotz and McCall, Daula and Moffitt, Argüden, and Hogan and Goon all assume that military personnel are risk neutral and that individuals base their decisions on comparisons of dollar values of various options. Though economists tend to assume that individuals are risk averse in decision-making, there is no *a priori* reason for assuming that this is the case for a population of military pilots. Even so, the estimated value of γ is not strongly inconsistent with a belief that the population is risk neutral. For example, with the γ estimated in Table 3.1, the certainty equivalent of a 50-50 lottery between prizes of $10,000 and $20,000 is $15,672 - essentially a risk neutral bet.

Though estimating the value of γ improves the fit of the model enough to reject the hypothesis that $\gamma = 1$, graphs of the predicted voluntary loss rates from 7 years of service to 19 years of service do not differ much from the case when $\gamma = 1$. The major changes in predictions occur after 20 years of service, when the pension becomes available if a person leaves the military. With γ fixed at one, the model overestimates departure rates in these years. When γ is estimated, the predictions in these years improve somewhat, though departure rates are still generally predicted to be too high. In fitting the loss rates after 20 years of service, a γ greater than one apparently allows greater valuation of the decision to remain in the military.

A literal interpretation of the k parameter would indicate that pension benefits are valued three times as highly as earned income. There are two ways of looking at why this value is so high.

First, with both the ALPA and CPS estimates of civilian income after a person leaves the military, incomes in the first few years of civilian life are substantially lower than military incomes. For personnel eligible for retirement, the predicted civilian salary may be much less than half the regular military compensation. These low predictions are based on the assumption that military experience will count for naught in civilian life - a reasonable assumption for those who become airline pilots, but not necessarily a good one for other types of employment. Despite these low predictions, people do leave the service, and in order for the model to predict that this is to their advantage, the k value must be high. In reality, however, many of the individuals who retire with a pension may be leaving for jobs that pay less than the military but do not require the radical cut in pay that the civilian income equations predict. In other words, the high k value might be a reflection of the higher civilian income potential of military retirees, rather than an indication of a higher valuation of pension income.[3]

A second explanation for the high k value is that it is a product of the simplifying assumption in the model that an individual's utility is based only on income. Suppose, instead, that utility is a simple function of income y and leisure time L,

$$U(L,y) = (Ly)^{1/2}.$$

With this utility function, a person would receive 20 units of utility when enjoying 12 hours of leisure and receiving $33.33 in wages from a job that pays $2.78 an hour.

[3]Hogan and Goon hoped that the Post-Service Earnings History File civilian income equation would help allow for the influence of military experience on civilian earnings. As mentioned earlier, however, the income predictions using the File did not allow as good a fit of observed departure behavior.

This allocation of time and leisure is shown in Figure 3.1 by line AB, which has slope -2.78 and is tangent to the utility curve at (12,33.33).

Suppose now that the individual could retire from the first job with a pension of \$15 a day. This is indicated by the distance BD in Figure 3.1, which shows that \$15 will be earned even with 24 hours of leisure. With this pension, a utility level of 20 can be maintained by working for a wage of \$1.20/hour, enjoying just over 18 hours of leisure, and receiving about \$7.00 in pay. The individual would be indifferent between remaining at the first job and working at the second while receiving the pension.

If we were observing this individual while assuming that his or her utility were based on the utility function

$$U = y + kp,$$

where y is income and p is the pension, we would compute 33.33 units of utility when the individual earns \$33.33 at the first job and 7+15k when he or she earns \$7.00 at the second. In order to believe that the individual is indifferent in the choice of jobs, we would assume that $k = 1.65$.

Thus, k values different from 1 may be the result of the fact that individuals value leisure time, not that they value pension income differently than other income.

The discount factor β is very precisely estimated both when γ is fixed and when γ is estimated. The .896 value when γ is estimated is close to the value frequently

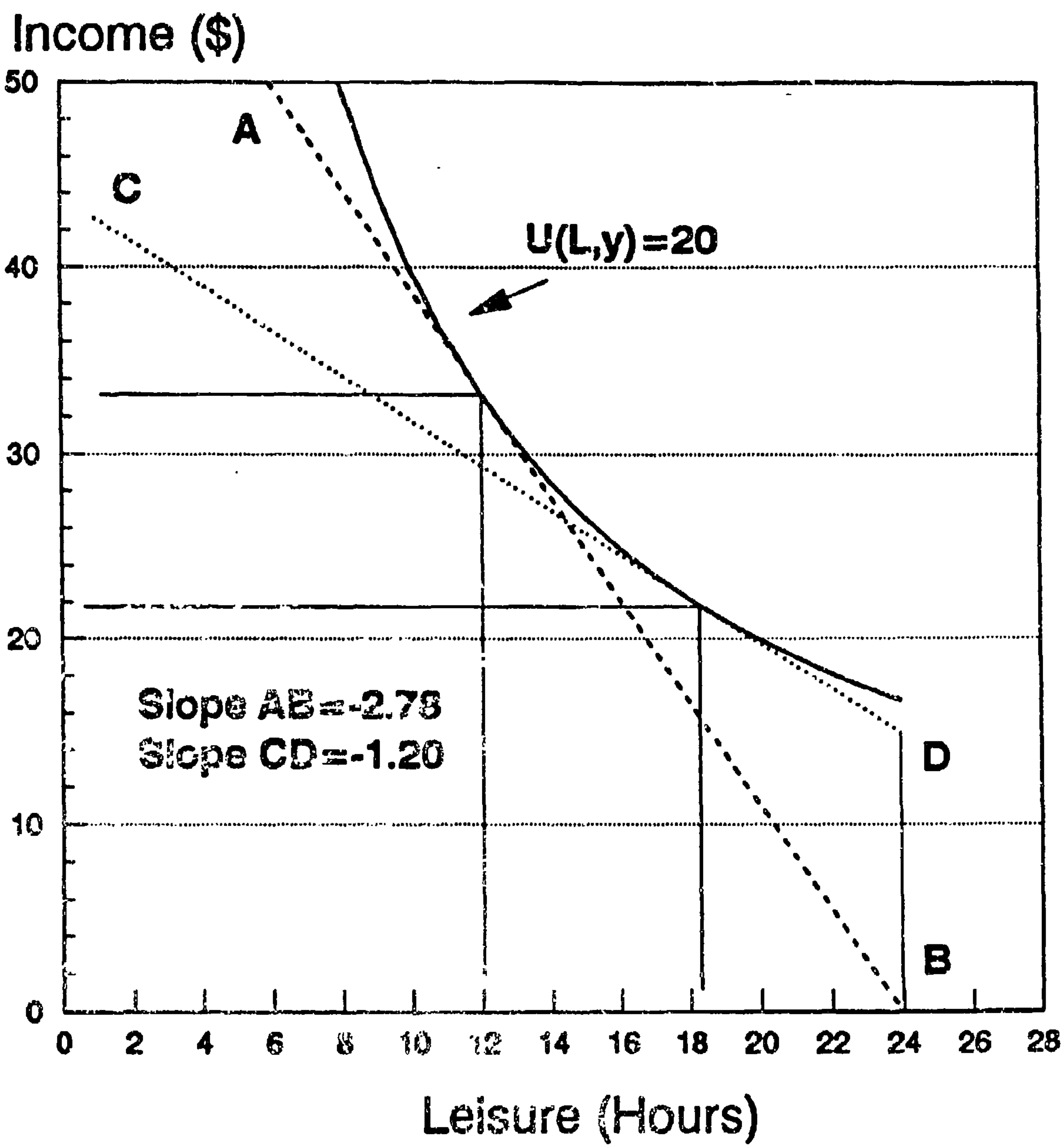

Figure 3.1. Labor-Leisure Diagram

assumed in studies of military personnel (β =.91).[4] Once again, it is not clear that this should be taken as a value that represents the "pure rate of time preference", independent of the decision to which it applies. As Stock and Wise point out, it is probably best to thir . .f it as a value applied to the retirement decision alone.

Table 3.2 shows the actual and predicted voluntary departure rates for Air Force pil..s using the second set of parameters in Table 3.1.

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[4]Matthew Black, in work done for QRMC V estimated the following equation for officer personal discount rates for officers (r given in percentage):

$$r = 11.9 - .14 \text{ (yrs of service)} + .001 \text{ (yrs of service)}^2.$$

This gives r=10.97% (β=.90) for officers with 7 years of service, r=9.5% (β=.913) for those with 20 years of service. Using this relationship, he estimated that 90% of the officer population had β in the range 88.9% to 92%.
See Atch 3 to Appendix I of [17].

TABLE 3.2

OPTION VALUE MODEL
Actual and Predicted Voluntary Loss Rates By Years of Service
Based on Single Year Model for 1988

Years of Service	Observations	Annual Loss Rates Actual	Annual Loss Rates Predicted	Cumulative Loss Rates Actual	Cumulative Loss Rates Predicted
7	110	0.555	0.372	0.555	0.372
8	64	0.500	0.359	0.777	0.597
9	45	0.200	0.343	0.822	0.736
10	36	0.250	0.299	0.866	0.815
11	50	0.200	0.242	0.893	0.859
12	25	0.240	0.188	0.919	0.886
13	45	0.067	0.133	0.924	0.901
14	58	0.069	0.076	0.929	0.909
15	64	0.016	0.036	0.930	0.912
16	85	0.012	0.007	0.931	0.912
17	85	0.024	0.000	0.933	0.912
18	96	0.000	0.000	0.933	0.912
19	116	0.034	0.000	0.935	0.912
20	103	0.408	0.473	0.962	0.954
21	59	0.492	0.436	0.981	0.974
22	43	0.302	0.458	0.986	0.986
23	25	0.040	0.230	0.987	0.989
24	20	0.200	0.271	0.990	0.992
25	30	0.167	0.273	0.991	0.994
26	16	0.375	0.419	0.995	0.997
27	7	0.143	0.156	0.995	0.997
28	12	0.250	0.187	0.997	0.998

Figure 3.2 shows the same information graphically[5]. The graph includes a 95% confidence interval around the actual rates. The departure behavior has some fairly complicated changes in the period from 7 to 28 years of service, but the option value

[5]Since all three models tested in this chapter underpredict departure rates in years 7 and 8, the cumulative departure rates in the following graphs start at 10 years of service. This is to better show the differences in the models in the years before vesting in the pension.

Figure 3.2
Actual and Predicted 1988 Voluntary Loss Rates

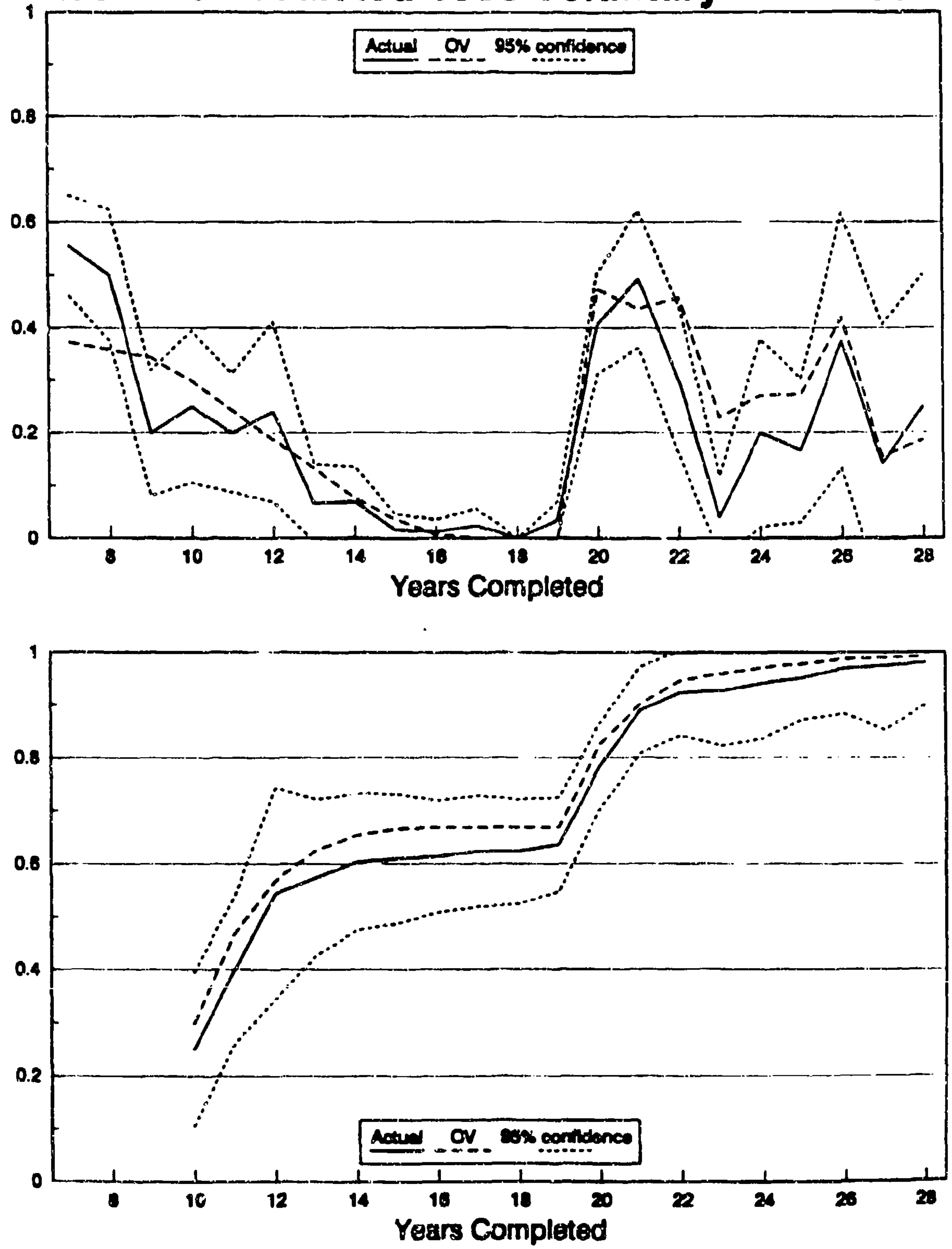


TABLE 3.3

OPTION VALUE MODEL
Parameter Estimates Based on Voluntary Departure Rates for Two Years

γ	k	β	ρ	σ_ν	σ_ϵ	$-\mathcal{L}$
1.97	3.16	.889	1*	.712	.816	788.97
(.202)	(.491)	(.012)		(.111)	(.116)	
1.92	3.20	.892	1.19	.468	.554	769.69
(.151)	(.050)	(.010)	(.073)	(.078)	(.088)	

*Parameter value fixed

The estimates for γ in both of the two year models are slightly higher than in the one year case, but not statistically significantly different. The k estimates are very close, and so are the estimates for β. It is a bit disappointing that the estimate of ρ is greater than one, but it is not "strongly" greater than one.[7]

As Stock and Wise did, we can determine the persistence of error disturbances by looking at the correlation of the ν's over the two years. This is given by

$$\frac{\rho\sigma_\nu^2}{\sigma_\nu(\rho^2\sigma_\nu^2+\sigma_\nu^2)^{1/2}} . \qquad (3.2)$$

For the random walk case, this is .657; when ρ is estimated, it is .708.

Table 3.4 compares the predicted voluntary loss rates for the two cases.

[7]Since option value calculations involve a finite time horizon (only until the time of a person's death), there is no problem with variances becoming infinite with this value of ρ.

TABLE 3.4

OPTION VALUE MODEL
Actual and Predicted Voluntary Loss Rates by Years of Service
Two-Year Estimation

Years of Service	Observations	Annual Rates			Cumulative Rates		
		actual	ρ=1	ρ est	actual	ρ=1	ρ est
7	110	.555	.370	.409	.555	.370	.409
8	64	.500	.358	.388	.777	.595	.638
9	45	.200	.341	.365	.822	.733	.770
10	36	.250	.294	.310	.866	.812	.841
11	50	.200	.233	.237	.893	.855	.879
12	25	.240	.176	.162	.919	.881	.899
13	45	.067	.120	.088	.924	.895	.907
14	58	.069	.064	.029	.929	.902	.910
15	64	.016	.027	.005	.93[illegible]	.905	.911
16	85	.012	.004	.000	.931	.905	.911
17	85	.024	.000	.000	.933	.905	.911
18	96	.000	.000	.000	.933	.905	.911
19	116	.034	.000	.000	.935	.905	.911
20	103	.408	.482	.473	.962	.951	.953
21	59	.492	.440	.473	.981	.972	.971
22	43	.302	.464	.450	.986	.985	.984
23	25	.040	.207	.080	.987	.988	.985
24	20	.200	.253	.135	.990	.991	.987
25	30	.167	.255	.137	.991	.993	.989
26	16	.375	.421	.362	.995	.997	.993
27	7	.143	.136	.050	.995	.996	.993
28	12	.250	.173	.149	.997	.997	.994

The estimates when ρ is fixed are essentially the same as in the one year estimation. When ρ is estimated, the model does slightly better at picking up variations in loss rates. For example, it does better at following the drop after 21 years of service and the large drop after 22 years of service than either the one year estimation or the two-year estimation with $\rho = 1$.

3.3 Dynamic Programming Model Results

Table 3.5 shows the parameter estimates for the dynamic programming model. Lines a) and b) in the table where λ is equal to zero represent estimates without a "taste" factor in an individual's utility.

TABLE 3.5

DYNAMIC PROGRAMMING MODEL
Parameter Estimates Based on Voluntary Loss Rates in One Year

	γ	k	β	σ	λ	$-\mathcal{L}$
a)	1*	1.59 (.238)	.852 (.012)	.413 (.031)	0*	509.26
b)	1.81 (.207)	1.44 (.184)	.852 (.012)	1.39 (.351)	0*	501.10
c)	1.91 (.384)	1.49 (.250)	.855 (.014)	1.55 (.666)	.019 (.052)	500.55

*Parameter value fixed

Once again, the estimate for γ is rather high, but not as precisely estimated as with the option value model. The values for k in all three variations of the dynamic programming model are much lower than with the option value, and not nearly as precisely estimated. Interestingly, in the work of Lumsdaine, Stock and Wise [33], the situation was the reverse: k values estimated with the dynamic programming model were significantly higher than those estimated with the option value model.

The estimation of β is close to the estimate with the option value model, and is once again very precise. The introduction of the taste factor almost doubles the computation time, but does little to improve the estimation of departures; this result is consistent with the work of Lumsdaine, Stock and Wise for civilian employees.

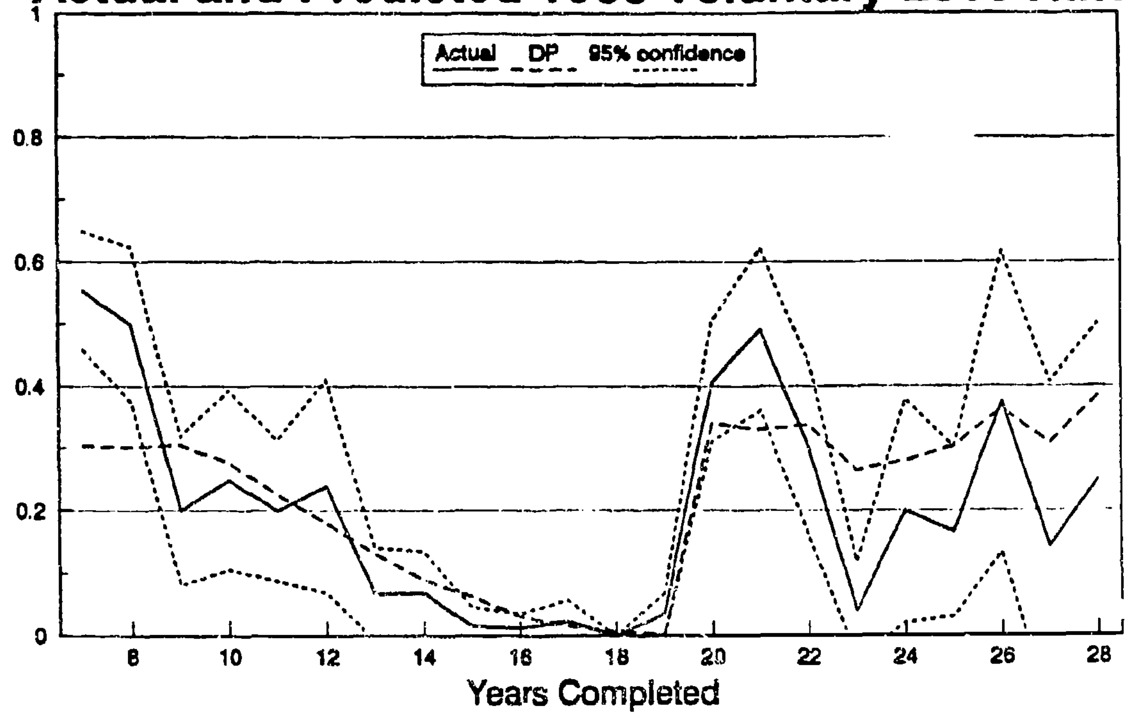
TABLE 3.6

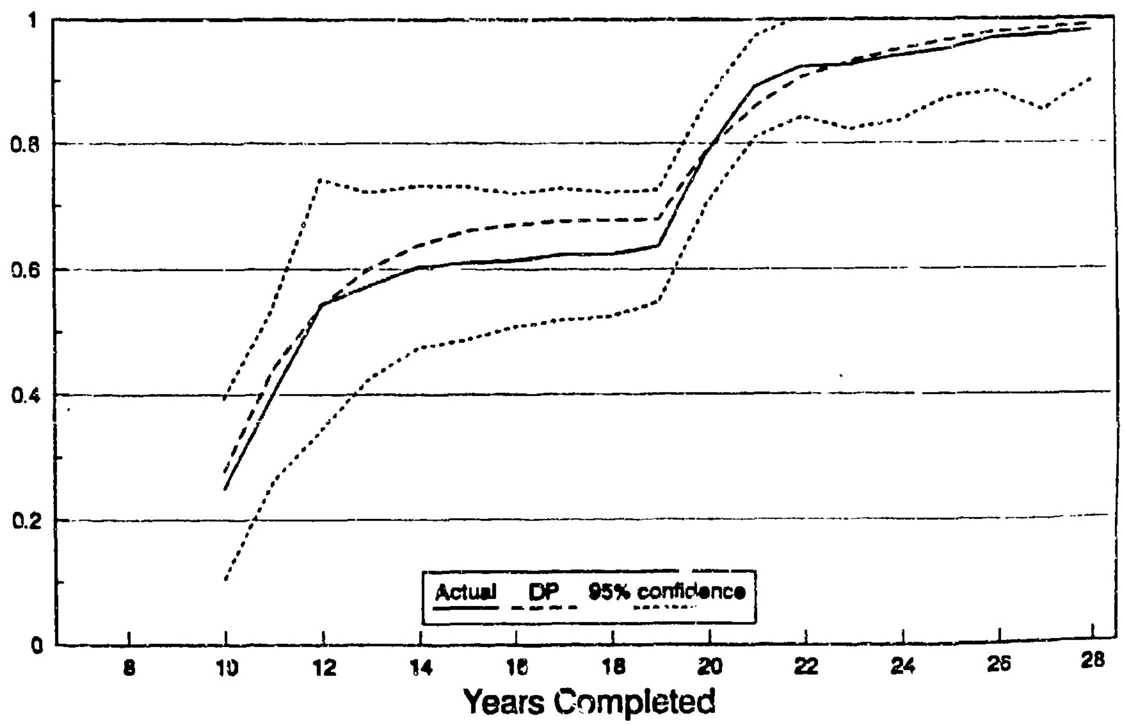
DYNAMIC PROGRAMMING MODEL
Actual and Predicted Voluntary Loss Rates

Years of Service	Observations	Annual Loss Rates Actual	Annual Loss Rates Predicted	Cumulative Loss Rates Actual	Cumulative Loss Rates Predicted
7	110	.555	.304	.555	.304
8	64	.500	.302	.777	.514
9	45	.200	.306	.822	.662
10	36	.250	.277	.866	.756
11	50	.200	.226	.893	.811
12	25	.240	.181	.919	.845
13	45	.067	.132	.924	.866
14	58	.069	.090	.929	.878
15	64	.016	.063	.930	.885
16	85	.012	.031	.931	.889
17	85	.024	.016	.933	.891
18	96	.000	.007	.933	.891
19	116	.034	.002	.935	.892
20	103	.408	.341	.962	.929
21	59	.492	.330	.981	.952
22	43	.302	.338	.986	.968
23	25	.040	.265	.987	.977
24	20	.200	.280	.990	.983
25	30	.167	.303	.991	.988
26	16	.375	.364	.995	.993
27	7	.143	.309	.995	.995
28	12	.250	.385	.997	.997

Table 3.6 lists the actual and predicted voluntary loss rates with the dynamic programming model, and Fig 3.3 displays the results graphically. Departure predictions in the first few years with this model are lower than with the option value model, but are very similar through 19 years of service. The dynamic programming model does not

Figure 3.3
Actual and Predicted 1988 Voluntary Loss Rates





predict as large an increase in departure rates after 20 years of service, and the predictions do not follow the pattern of changes after 21 years of service as well as the option value model does. The predictions of this model fall outside the 95% confidence interval at 7, 8, 15, 21, and 23 years of service.

3.4 ACOL Model Results

The parameter estimates for the ACOL model are listed in Table 3.7.

TABLE 3.7

ACOL MODEL PARAMETER ESTIMATES

α_0	α_1	$-\mathcal{L}$
.669 (.075)	5.01 (.007)	529.91

Annualized Cost of Leaving values calculated using r=.1
Monetary values are in $100,000

The ACOL model does substantially worse in predictions than the other two models in terms of the value of the log likelihood function. Table 3.8 lists the actual and predicted voluntary loss rates, and Figure 3.4 shows what they look like. The ACOL model overpredicts departures significantly in years 12 through 18, and does not follow the patterns of departure after 22 years at all, instead almost "averaging out" those rates.

TABLE 3.8

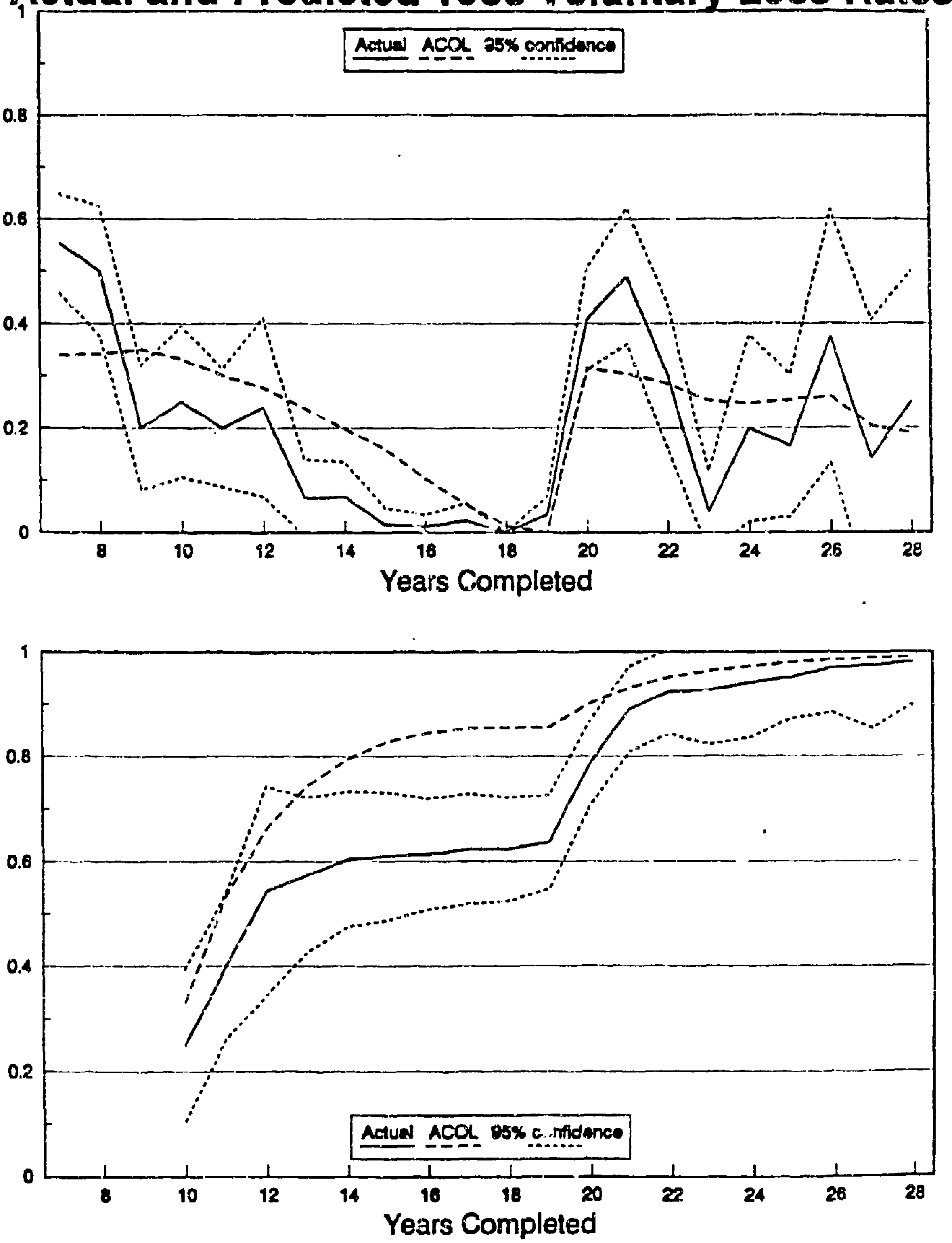
ACOL MODEL
Actual and Predicted Voluntary Loss Rates

Years of Service	Observations	Annual Loss Rates Actual	Annual Loss Rates Predicted	Cumulative Actual	Cumulative Predicted
7	110	.555	.341	.555	.341
8	64	.500	.342	.777	.566
9	45	.200	.350	.822	.718
10	36	.250	.332	.866	.812
11	50	.200	.301	.893	.869
12	25	.240	.277	.919	.905
13	45	.067	.239	.924	.928
14	58	.069	.199	.929	.942
15	64	.016	.161	.930	.951
16	85	.012	.104	.931	.956
17	85	.024	.053	.933	.959
18	96	.000	.014	.933	.959
19	116	.034	.000	.935	.959
20	103	.408	.316	.962	.972
21	59	.492	.304	.981	.981
22	43	.302	.286	.986	.986
23	25	.040	.253	.987	.990
24	20	.200	.247	.990	.992
25	30	.167	.254	.991	.994
26	16	.375	.260	.995	.996
27	7	.143	.206	.995	.997
28	12	.250	.190	.997	.997

3.5 Departure Rates versus Voluntary Loss Rates

The tables and graphs presented so far have shown voluntary loss rates for the pilot sample in 1988 - that is, the departure rates for pilots who were not under any service commitment. There are, however, several ways for officers to incur additional service commitments. Acceptance of promotion to major, as we have seen, requires that an individual remain in the service for two more years. If an officer attends certain

Figure 3.4
Actual and Predicted 1988 Voluntary Loss Rates



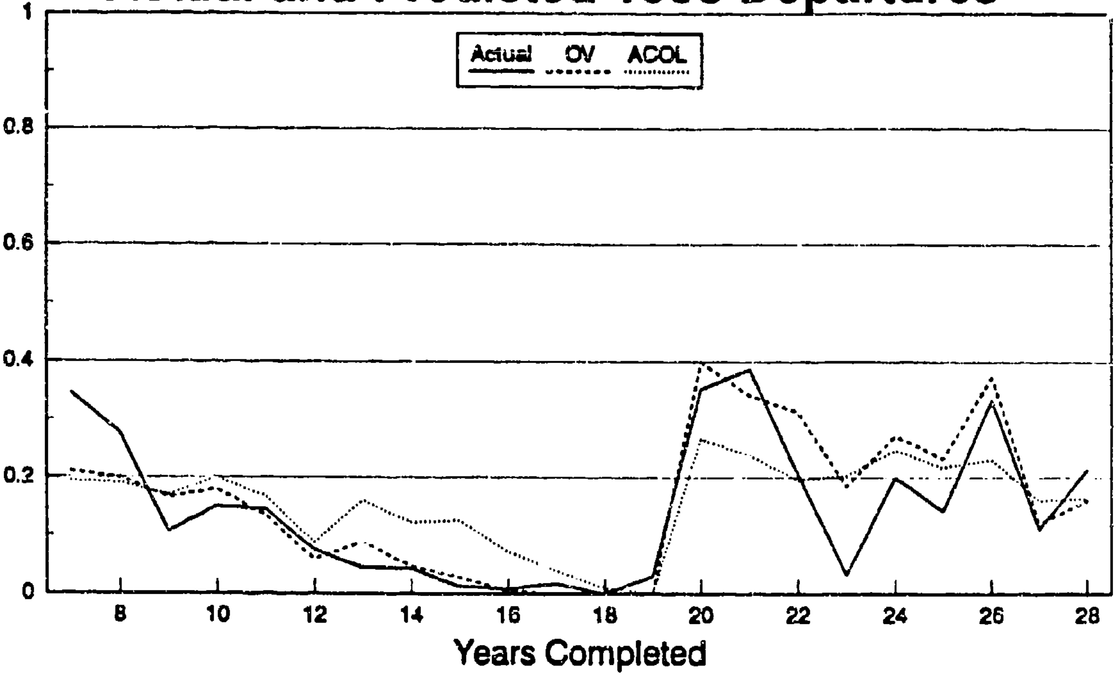
military training (such as schools for professional military education), he or she also incurs an additional commitment. The Air Force pays for education leading to advanced degrees for many officers, and this carries with it the obligation to serve two months for each month in school, up to a maximum commitment of five years.[8]

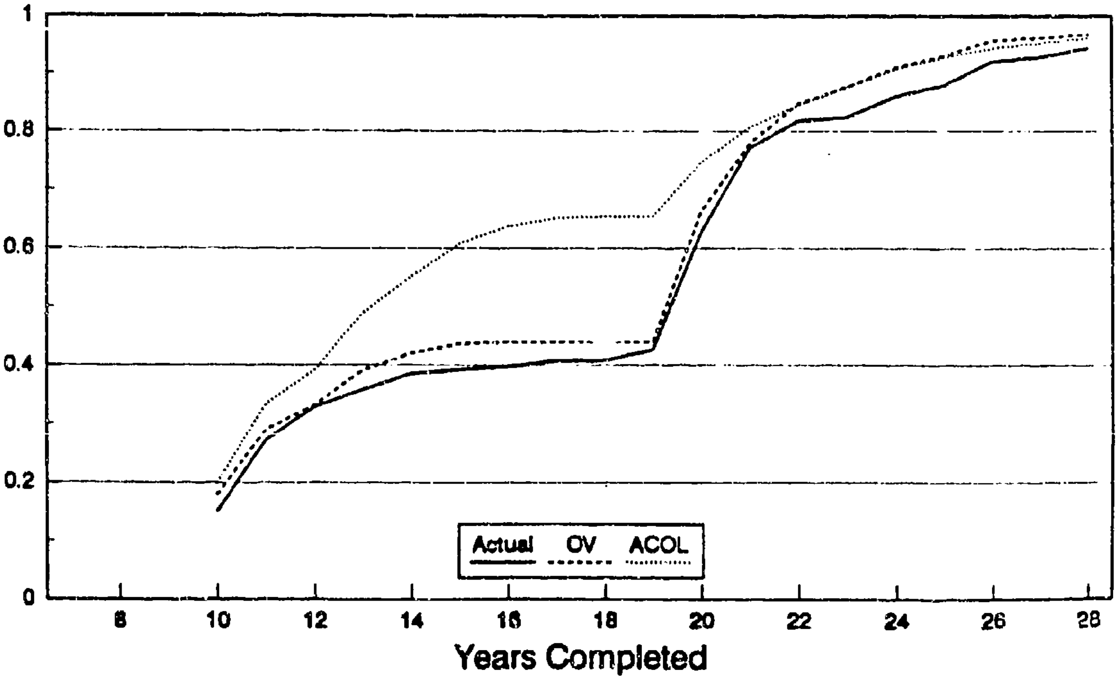
Many of these commitments can be reduced or forgiven in certain circumstances, and commitment obligations in the pilot population change throughout a fiscal year. Possibly in recognition of the changing obligations of officers, Congress and the Air Force have historically not taken active duty service obligations into account when addressing the pilot retention problem, and have used instead the simple departure rate (number of pilots who leave out of the pilot population in a given year of service). One measure of pilot retention that is frequently referred to in Air Force documents is the Cumulative Continuation Rate (CCR), which is the implied percentage of pilots present after six years of service who will remain through eleven years of service if the departure rates for each years-of-service cohort in a given year are assumed to remain constant. This statistic is based on departure rates, not on voluntary loss rates.

In Figure 3.5, actual departure rates and the rates predicted by the option value and ACOL models are shown. The graphs are based on the predicted voluntary loss rates multiplied by the ratio of pilots with commitments to those without commitments. The actual departure rates show a slightly smoother rate decline than the actual voluntary loss rates illustrated in previous figures, and the jump at twelve years of service is missing. The ACOL model in this representation continues to overpredict significantly

[8]Air Force Regulation 36-51 governs the commitments Air Force members incur.

Figure 3.5
Actual and Predicted 1988 Departures





from 12 to 18 years of service, but the option value predictions follow the actual behavior rather well.

The simple departure rate will be useful in the next chapter when the predicted effects of the introduction of the 1989 pilot bonus for the three models are compared.

Summary

Table 3.9 provides a summary of the single year estimations for the three models under investigation. A chi-square goodness of fit statistic is included in the table to provide another measure of the comparative performance of the models. The statistic is calculated as

$$\chi^2 = \sum_{j=7}^{j=28} n_j \frac{(r_{aj}-r_{pj})^2}{r_{pj}} \tag{3.3}$$

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.

In terms of the likelihood function values, the option value and dynamic programming models are very close, and both are far superior to the ACOL model. The dynamic programming model does worse than the option value model in terms of the chi-square measure primarily because of its underestimates of departures for the 7,8 and 21 years of service groups. Once again, both models do much better than the ACOL model.

Conclusion

The results of this chapter provide initial evidence that the option value and dynamic programming models give more accurate representations of pilot behavior than the ACOL model. For more confidence in this conclusion, we need to attempt some out-of-sample predictions, and that is the goal of the next chapter.

CHAPTER FOUR

PREDICTION

In the last chapter, we used three models of behavior to fit the 1988 voluntary loss rate and departure patterns of a sample of MAC and SAC pilots. The predictions of both the option value model and the dynamic programming model fit the actual patterns fairly well, and both performed much better than the ACOL model.

Since we are interested in the effects future changes in compensation will have on the decision to leave the military, it is important to see how well the models work in predicting changes for cases other than the one for which the parameters were estimated. There are two ways to do this. The first is to use the estimated parameters of the models on a different sample of pilots; the second is to see how well the models do in predicting the known effects of previous changes in compensation on the same sample. For the former test, we will analyze the 1988 departure patterns sample of Tactical Air Command (TAC) pilots; for the latter, we will use the introduction of Aviator Continuation Pay in 1989.

After investigating these examples of out-of-sample predictions, we will compare the predicted effects of the introduction of the pilot bonus in 1988, to see if models other than the ACOL model might have led to a different decision about implementing the bonus.

4.1 Out of Sample Predictions with TAC Pilots

The pilot sample provided by the Air Force Military Personnel Center includes 1078 pilots in the Tactical Air Command. Most pilots in TAC fly fighter-type aircraft, which require only one person crews, though some fly versions of aircraft that are also used in MAC and SAC, such as the EC-135 (a military version of the Boeing 707) and the C-130, which require both a pilot and a co-pilot as well as other crewmembers.

Since the higher paying civilian airline jobs involve flying aircraft that require two pilots, it might be thought that military pilots with experience managing a flight crew have an advantage over fighter pilots when seeking an airline position, but this is not necessarily the case, and previous experience in flying large aircraft is not a requirement for any airlines. What counts more is the number of flying hours an individual has, since most flying skills are transferable among aircraft. In fact, it is not unusual for civilian airline pilots to simultaneously have fighter aircraft positions in Air National Guard or Air Force Reserve units.

Though loss rates by year-of-service cohorts were not available for the Air Force TAC population, the Cumulative Continuation Rate for TAC pilots was close to that of MAC and SAC pilots in 1988 and 1989.[1]

Since the potential for civilian airline positions for TAC pilots is just as good as it is for MAC and SAC pilots, and because past cumulative departure rates have been similar, the TAC sample is a reasonable one for an out-of-sample test.

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[1]TAC pilots had CCRs of .40 in 1988 and .33 in 1989;
SAC pilots had CCRs of .39 in 1988 and .31 in 1989;
MAC pilots had CCRs of .32 in 1988 and .32 in 1989.

The 1988 parameters for the single year option value model, the dynamic programming model without the taste parameter, and the ACOL model were used to predict 1988 voluntary loss rates for the TAC population. Summary statistics for the predictions are shown in Table 4.1.

Table 4.1

Summary Statistics for Out-of-Sample Predictions
TAC Sample

Model	$-\mathcal{L}$	χ^2
Option Value	315.14	25.28
Dynamic Programming	323.92	38.58
ACOL	345.20	43.94

$\mathcal{L}$ is the value of the log likelihood function
Sample size is 1078 (743 allowed to depart in 1988)

Figures 4.1, 4.2, and 4.3 represent the annual and cumulative voluntary loss rates predicted by the three models. The rise in the actual loss rate after twelve years of service is more pronounced for this sample than it was for the sample used in estimating the parameters, and none of the models pick up the spike, but this is not a surprise since the decision to leave after 12 years of service involves consideration of factors beyond compensation.

The predicted loss rates of the option value model (figure 4.1) and the dynamic programming model (Figure 4.2) are very close from 7 years of service through 19 years

Figure 4.1
TAC Voluntary Loss Rates

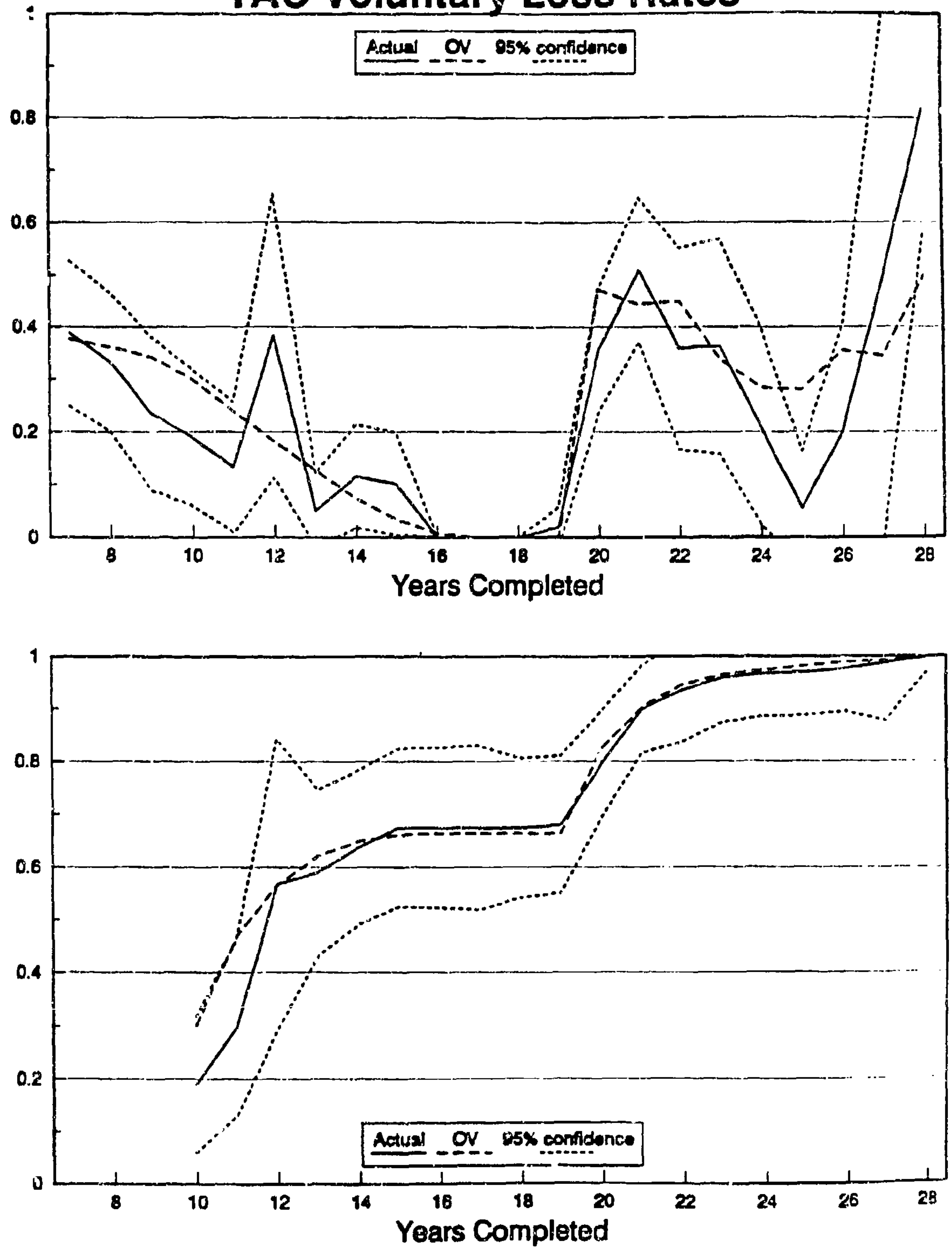
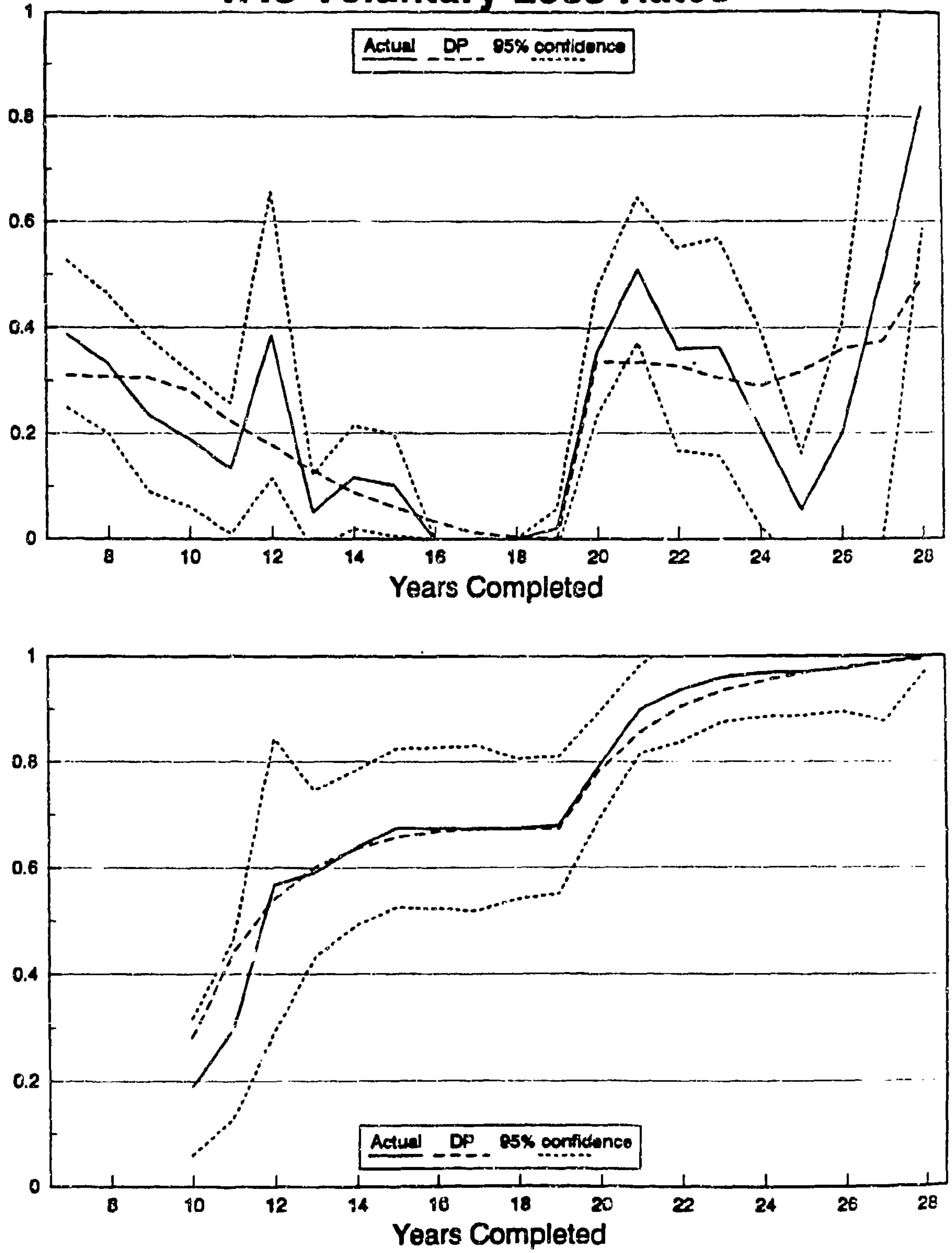


Figure 4.2
TAC Voluntary Loss Rates



of service, though the dynamic programming model underpredicts noticeably at 7 years of service. The option value model seems to do a slightly better job of picking up the pattern of changes after 20 years of service, though this is an admittedly subjective assessment, but both pick up the general increases after 25 years of service. The option value predictions are outside the 95% confidence interval at only three places (13, 25 and 28 years of service), and the dynamic programming model misses at five.

The ACOL model (Figure 4.3) overpredicts loss rates substantially from 12 years of service to 17 years of service (as it did in the estimated sample), and exhibits very little change in departure patterns after 22 years of service.

To make the comparisons a little easier, the top panel of Figure 4.4 graphs the option value and dynamic programming predictions together, and the bottom panel combines the option value and ACOL predictions.

When departure rates are considered instead of voluntary loss rates, the superiority of the option value and dynamic programming models is also clear. Figure 4.5 compares the predicted departure rates of the option value model to those of the dynamic programming model. Figure 4.6 compares the option value and ACOL models.[2] The ACOL model overprediction from 12 through 17 years of service remains, and the predicted cumulative departure rate is well above the actual cumulative rate from 12 through 20 years of service.

[2]Recall that the departure rates are found by multiplying the voluntary loss rate by the proportion of pilots in a given year who were not under an obligation to remain in the service. This gives the proportion of pilots in a cohort who leave.

Figure 4.3
TAC Voluntary Loss Rates

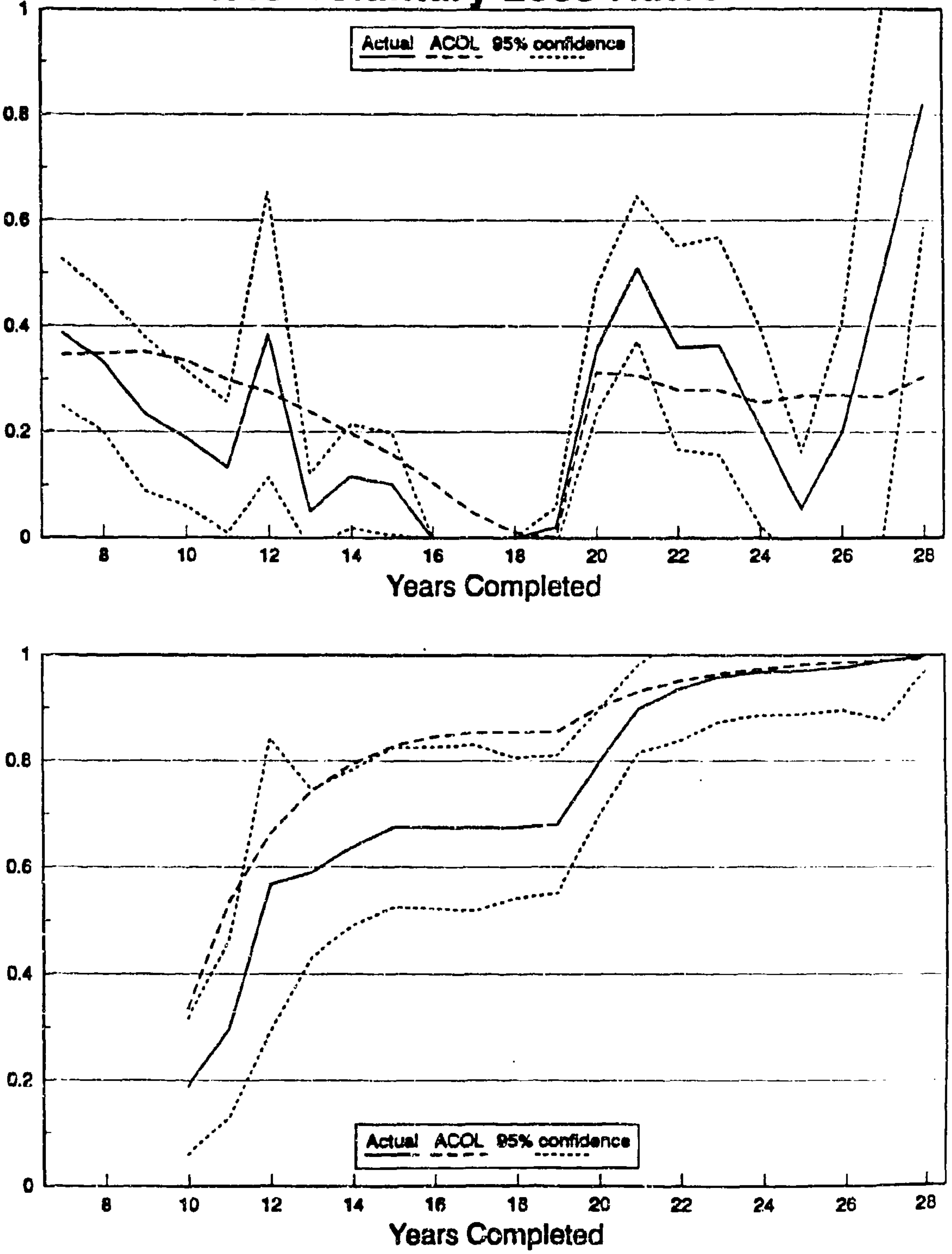
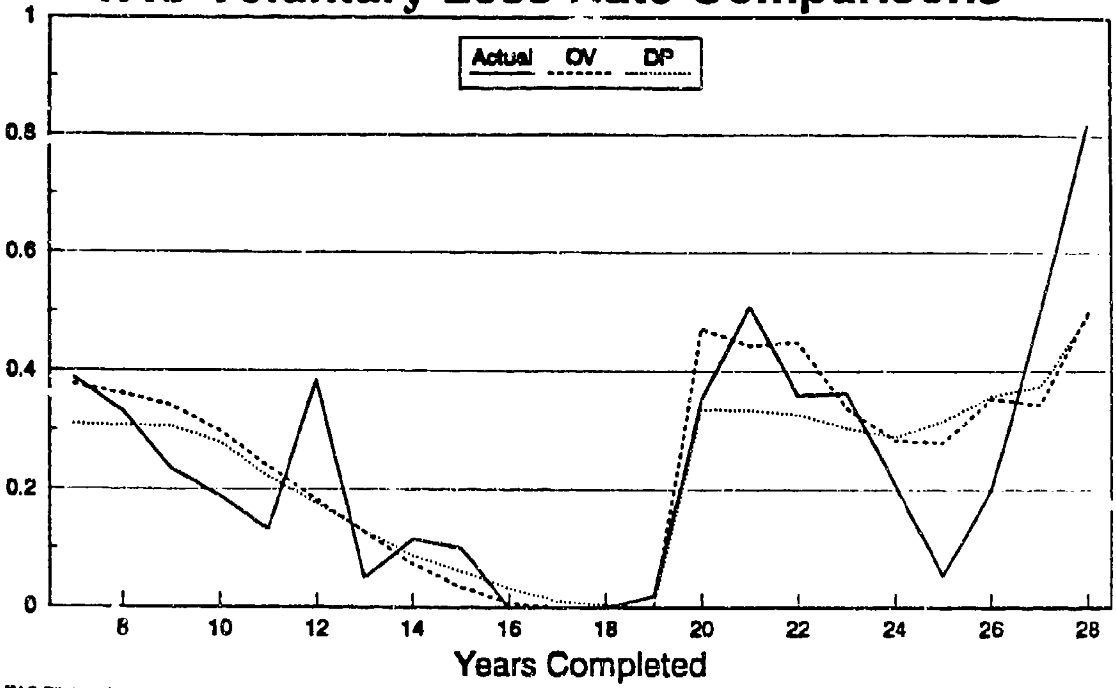
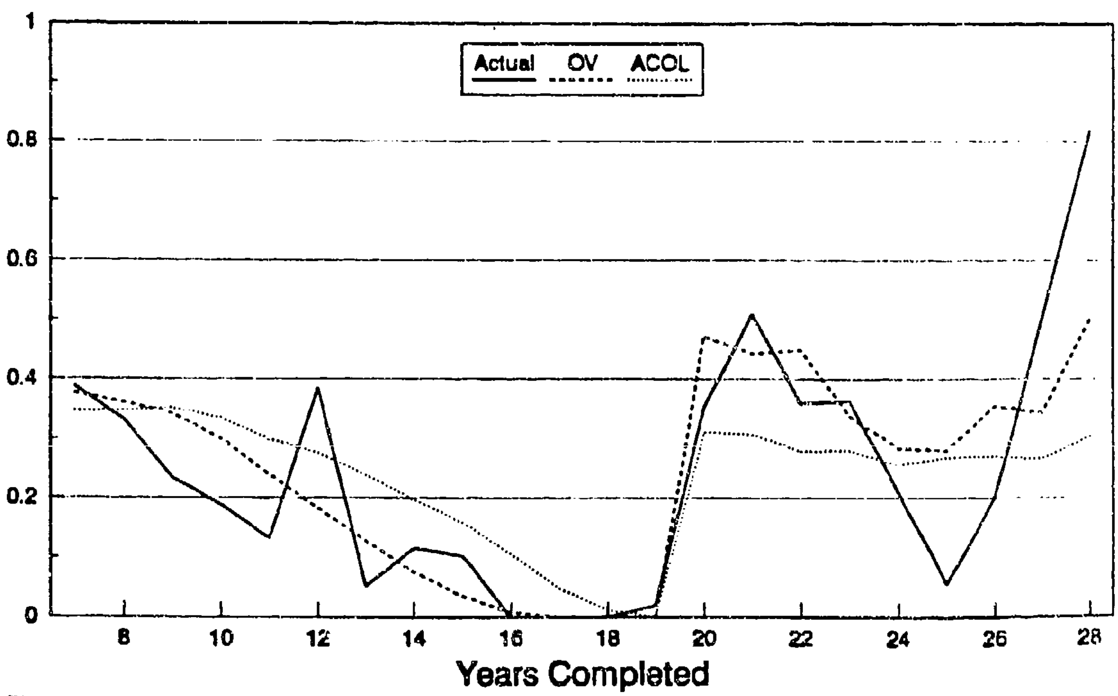


Figure 4.4
TAC Voluntary Loss Rate Comparisons

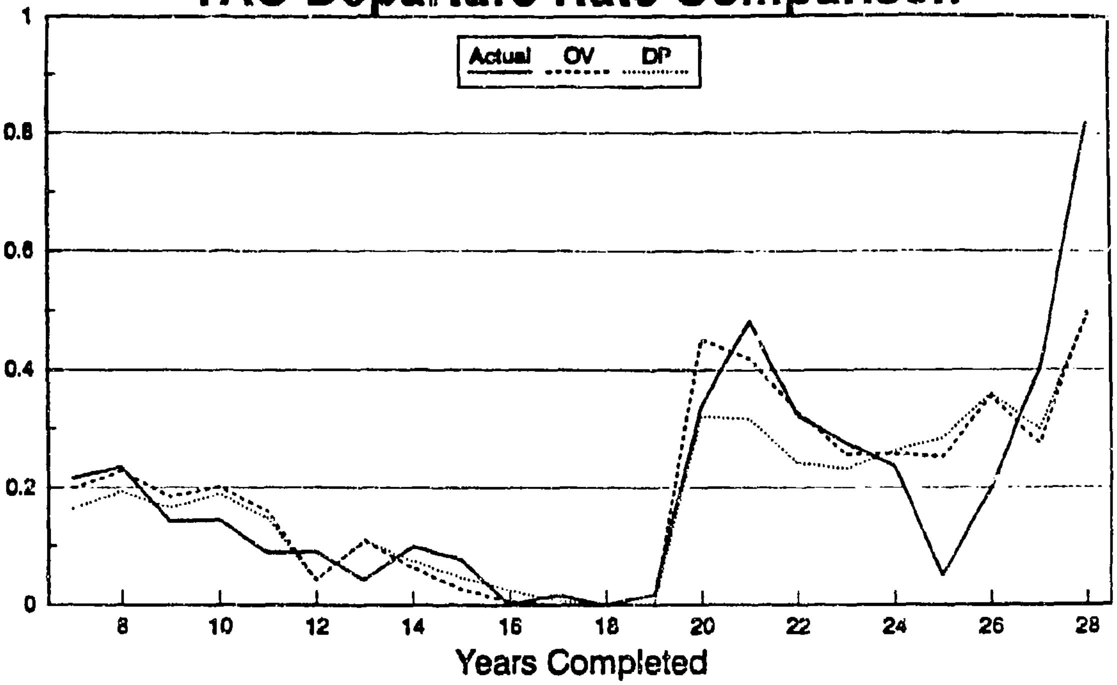


TAC Pilots only

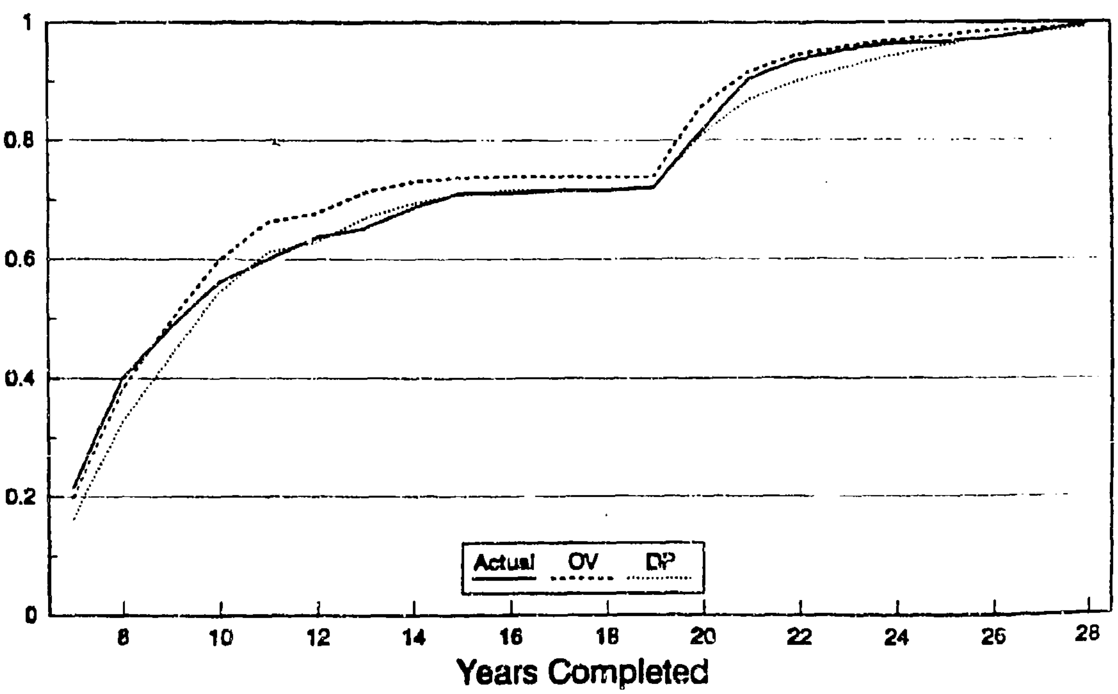


TAC Pilots only

Figure 4.5
TAC Departure Rate Comparison

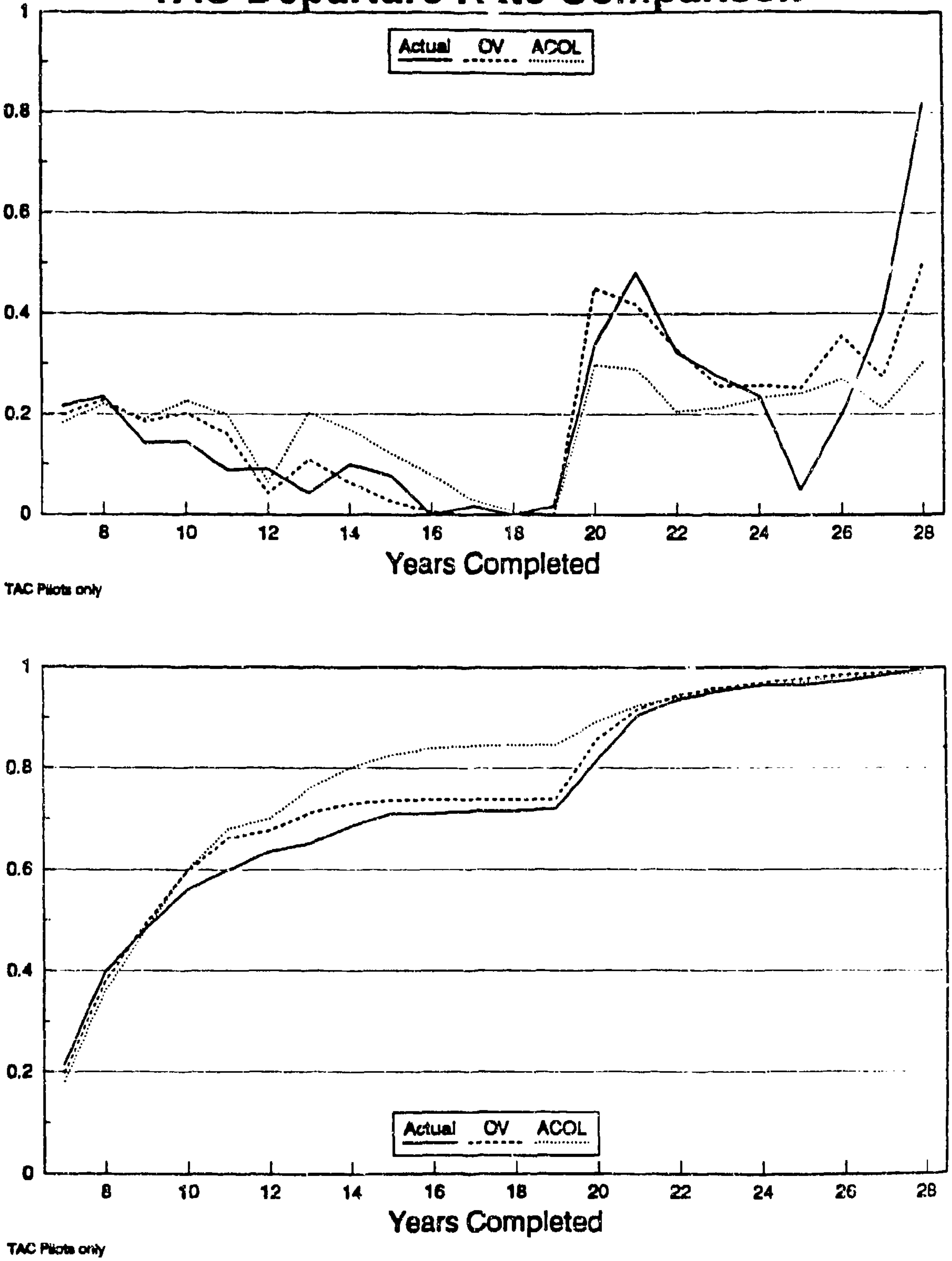


TAC Pilots only



TAC Pilots only

Figure 4.6
TAC Departure Rate Comparison



Considering the fact that the graphs for the TAC sample are based on parameters that were not estimated for that sample, the fit of the option value and dynamic programming models in statistical measures and the appearance of the departure rate graphs is fairly impressive, and is evidence that these models capture the true behavior of the sample better than the ACOL model does.[3]

4.2 "Out-of-Sample" Predictions With Aviator Continuation Pay

Aviator Continuation Pay (ACP) was implemented in January, 1989, with five criteria for eligibility [8]:

1. The pilot must be of rank Lt Colonel or below
2. The pilot must fly fixed wing aircraft (as opposed to helicopters)
3. The pilot must be entitled to Aviation Career Incentive Pay[4]
4. The pilot must have completed at least 6 years, but less than 13 years of total active federal service
5. The initial Active Duty Service Commitment (ADSCD) incurred for pilot training must be completed.

Annual amounts of the bonus, which are received through the fourteenth year of service, are shown in Table 4.2.

[3]When ACOL parameters are estimated for the TAC sample, there is hardly any improvement over the log likelihood value obtained using the MAC and SAC parameters. It increases from -345.20 to -344.55.

[4]This prevents the bonus from being available to pilots who have not completed the "gate" credit described in Chapter One.

Table 4.2
Aviator Continuation Pay

Years Completed	Annual Payment
6	$12,000
7	12,000
8	11,000
9	11,000
10	9,500
11	8,000
12	6,500

Source: FY91 ACP Fact Sheet

The beginning of the ACP program was announced to eligible pilots in letters sent to them at the end of December 1988. Although various monetary remedies for the loss of pilots had been discussed before that time, and there were officers who had participated in surveys about the effects of some type of bonus, there was little indication before the letter was sent that anything like ACP would be approved by Congress. It is therefore extremely unlikely that pilots contemplating leaving the Air Force before October of 1988 delayed their departure in anticipation of receiving large bonuses if they remained.[5]

The letters announcing the bonus also informed eligible pilots that the decision to accept ACP had to be made by the end of March of 1989. There was no guarantee that the bonus would be available after that date, and even if it was, its value might be lower.

[5]Recall that the Longitudinal Cohort File is updated in October.

Thus, the departure patterns recorded for October 1989 should reflect the initial effects, if any, that ACP had.

It is important to note that the existence of active duty service obligations other than the one incurred from pilot training does not make a person ineligible for the bonus. Thus, for example, a pilot at nine years of service who has just completed two years of study for a Master's Degree under Air Force sponsorship and therefore has four years of commitment (through thirteen years of service) anyway, could still accept the pilot bonus and gain the benefits of five years of the additional pay at the cost of only one extra year of commitment.

Because of these other commitments, numbers related to the implementation of ACP can sometimes be confusing. For example, when the bonus was introduced in 1989, only 2,501 pilots in the 6 to 12 year cohorts did not have active duty service obligations. However, 5,512 were eligible for Aviator Continuation Pay, and 3,650 accepted it.

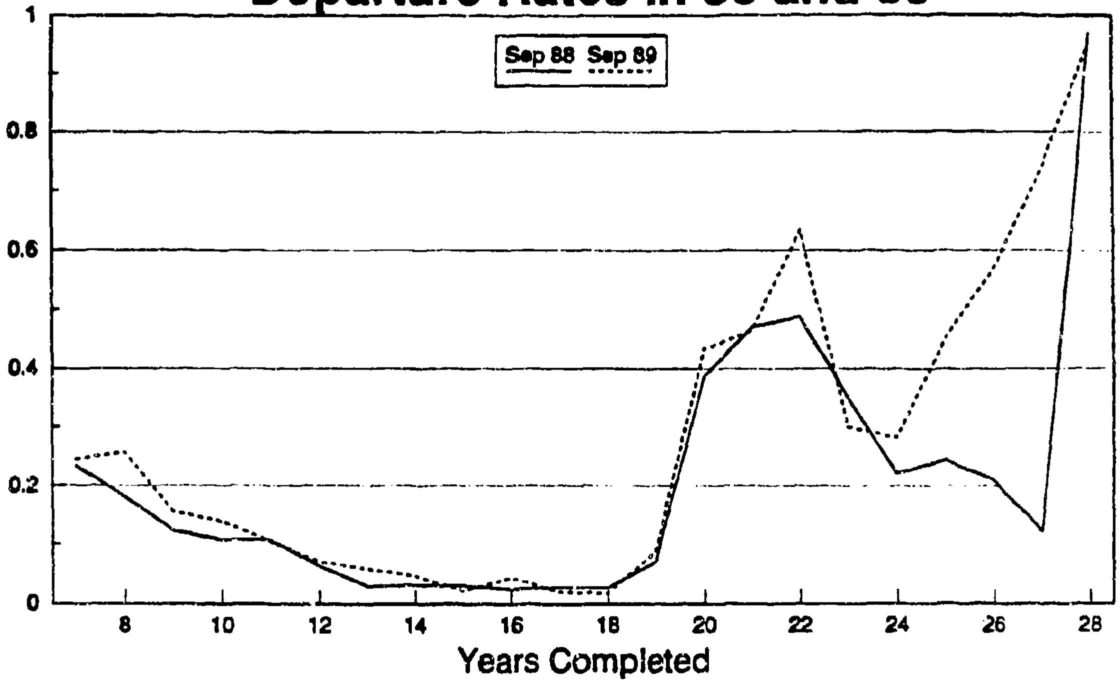
The goal of ACP was to encourage the "marginal" pilot, with no commitment, to stay in the service because of increased pay. The decision such an individual faces is essentially between leaving the Air Force now or remaining until 14 years of service are completed. Those who already have a commitment, on the other hand, must decide to accept the bonus and add more years to their commitment or reject the bonus in order to retain the option to leave before completing 14 years. Some individuals with commitments really have no decision to make at all (at least if they are rational): if a previous commitment requires them to complete 14 years of service, they can accept the bonus for "free".

Since estimation of the models used in this chapter is based on observations of the decision to leave the military under the assumption that the decision is made because civilian life will provide more utility, it is not possible to predict the reactions of those who are eligible to accept the bonus but who are not eligible to leave for a civilian job. For the military personnel planner, this can be seen as a limitation of these models, since it may be as important to know how many pilots can be induced to stay in the Air Force for a given amount of time regardless of their current commitment as it is to know how many with the option to leave now can be convinced to stay instead.

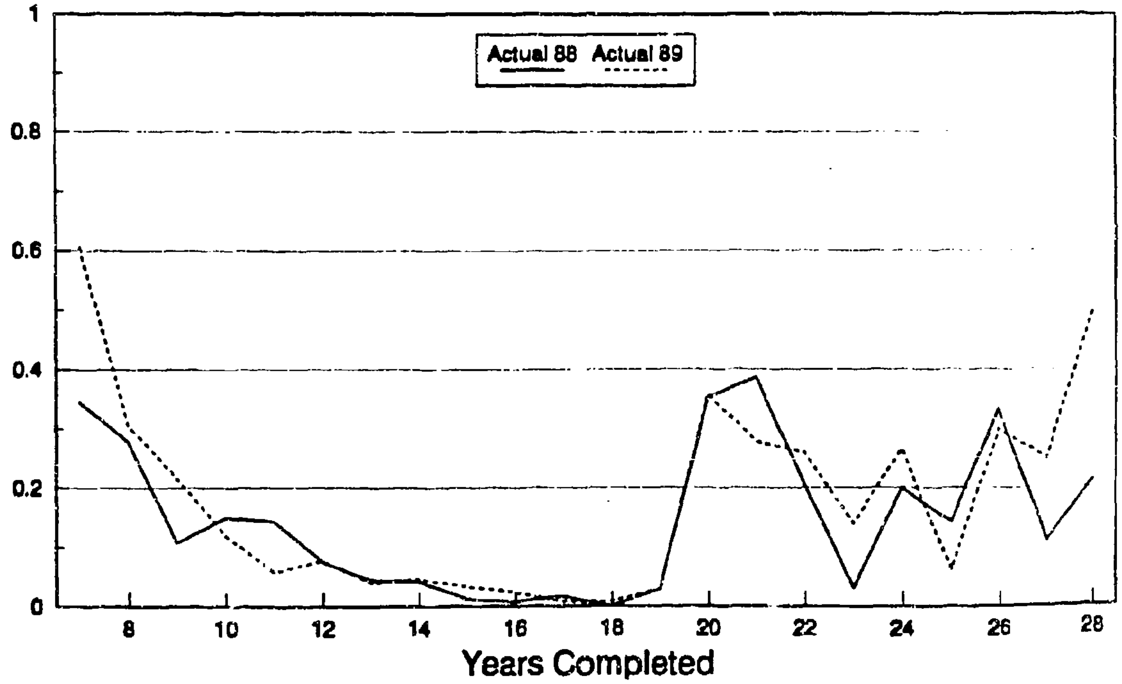
The outcome of the introduction of ACP was not what was expected. The top panel of Figure 4.7 shows the actual 1988 and 1989 departure rates for all Air Force pilots in those two years [9]; the bottom panel shows the departure rates for pilots in the sample of MAC and SAC pilots. In the whole population, most of the cohorts specifically targeted by the bonus - those who had completed between 7 and 12 years of service - experienced slight increases in departure rates from 1988 to 1989. Except for a noticeable drop after eleven years of service, the same is true of the MAC and SAC pilots.[6] In general, Air Force planners feel that the introduction of the bonus "forced"

[6]Despite this, the Air Force does not consider the program a total failure. Those who did accept the bonus are still committed to remain in the military until they complete 14 years of service. Knowing that there will be a pool of committed pilots available for the next several years does help the Air Force plan future force changes.

Figure 4.7
Departure Rates in 88 and 89



Total Pilot Population



MAC and SAC Sample

individuals considering leaving the military to make their decision. Those who were leaning toward leaving did so, rather than accept the bonus with the associated service commitment or delay the decision for another year and serve without accepting the bonus in order to retain the option to leave at a later date. Those who accepted the bonus were probably going to remain anyway, and there were very few pilots who refused the bonus but remained in the service.[7]

Since all of the models of departure behavior we are considering are based on the assumption that an increase in compensation will provide motivation to remain in the military, it is too much to ask that any of them pick up the increases in departure rates that were actually observed for some cohorts in the sample in 1989. Nonetheless, the predicted departure rates for 1989 can help us evaluate the performance of the models by showing the relative magnitude of the predicted improvements in retention.

In the computer program that calculated the effects of the pilot bonus, the bonus amounts were introduced in such a way as to take into account the fact that in order to receive them, an individual had to agree to remain in the service through the fourteenth year. For example, if a pilot who had completed 8 years of service compared the utility of that decision with the utility of leaving after 10 years of service, the bonus amounts were not included in the utility of either decision, since in order to retain the option of leaving after 10 years, the individual would have to refuse the bonus. For the same

[7]These remarks are based on conversations with Maj Bowman of AFMPC/DPMATM.

bottom panel of Figure 4.9 the results with the ACOL model. Because actual loss rates increased in 1989, the predictions without the bonus fit the data slightly better than the predictions with the bonus.

As indicated by the log likelihood and chi-square values, the general fit of the option value and dynamic programming models is very similar, and both perform better than the ACOL model.[9] As with the 1988 sample, the ACOL model significantly overpredicts loss rates between 12 and 17 years of service. Figure 4.10 compares the option value and ACOL model fits in terms of departure rates instead of voluntary loss rates. Both models miss the very high departure rates after 7 and 8 years of service, but the option value model does much better after that point.

To conclude this parade of graphs for the out-of-sample test, Figure 4.11 shows the actual and predicted changes in departure rates from 1988 to 1989.[10] The top panel shows the changes from 7 through 28 years of service; the bottom panel covers 7 through 14 years of service to emphasize the changes for pilots affected by Aviator Continuation Pay. In this graph, the lines represent 1989 departure rates minus 1988 departure rates, so that an increase in departure rates shows up as a positive point. For example, actual

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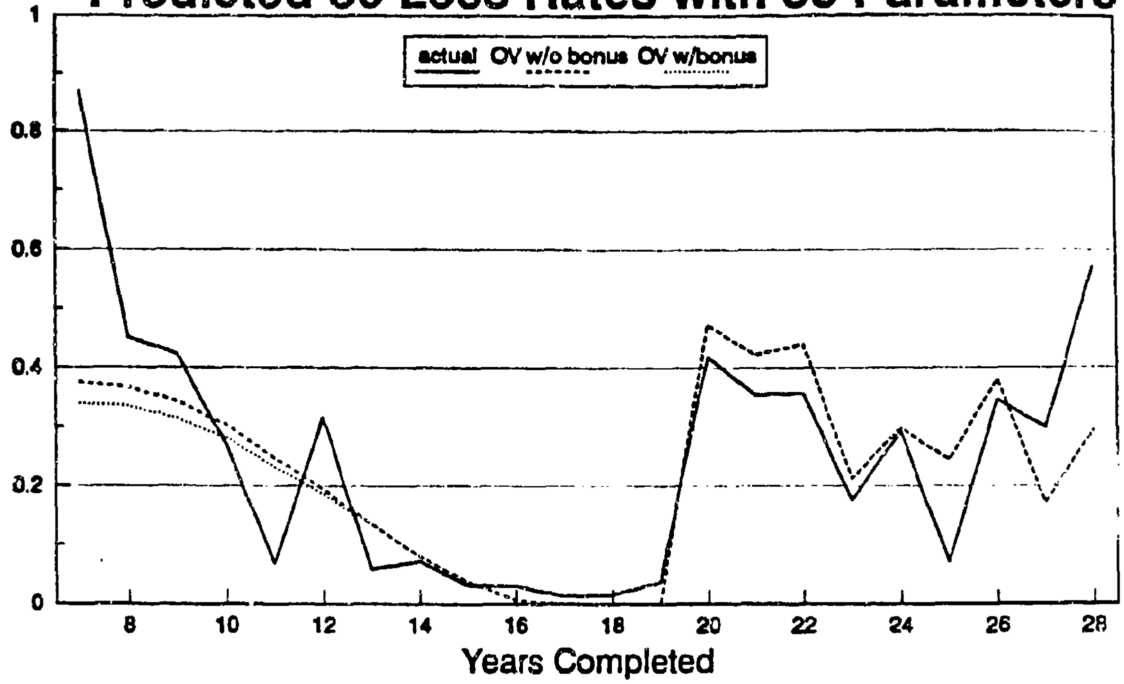
[9]When the ACOL model is estimated for 1989 with the bonus, the parameters are not significantly different from those estimated for 1988 without the bonus. The value of the likelihood function hardly changes, increasing to -468.1.

[10]The 1989 departure rates are calculated from the predicted 1989 voluntary loss rates and the 1988 proportion of pilots eligible to leave the military. This is done because it is not clear how the ratio would change in 1989 with the introduction of the bonus. This calculation may overestimate the 1989 departure rate for the following reason: those who accept the bonus will be listed as ineligible to depart in 1989, so the proportion of pilots eligible to leave may decrease in that year. This decrease would lower the calculated departure rate.

Figure 4.8
Predicted 89 Loss Rates with 88 Parameters



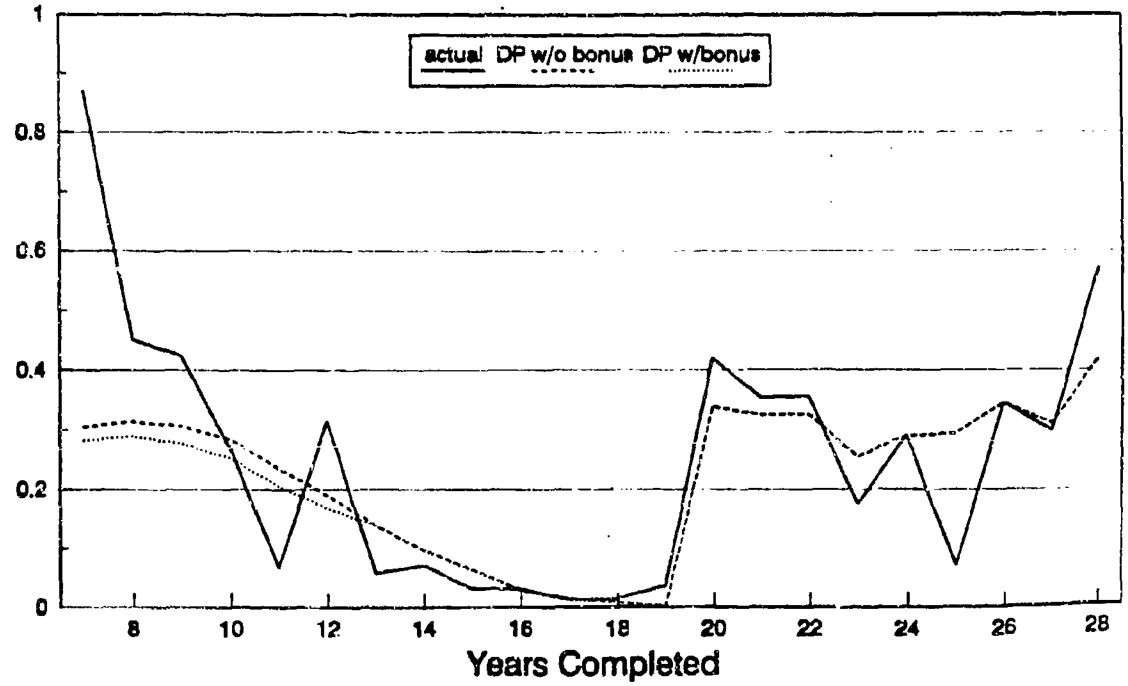
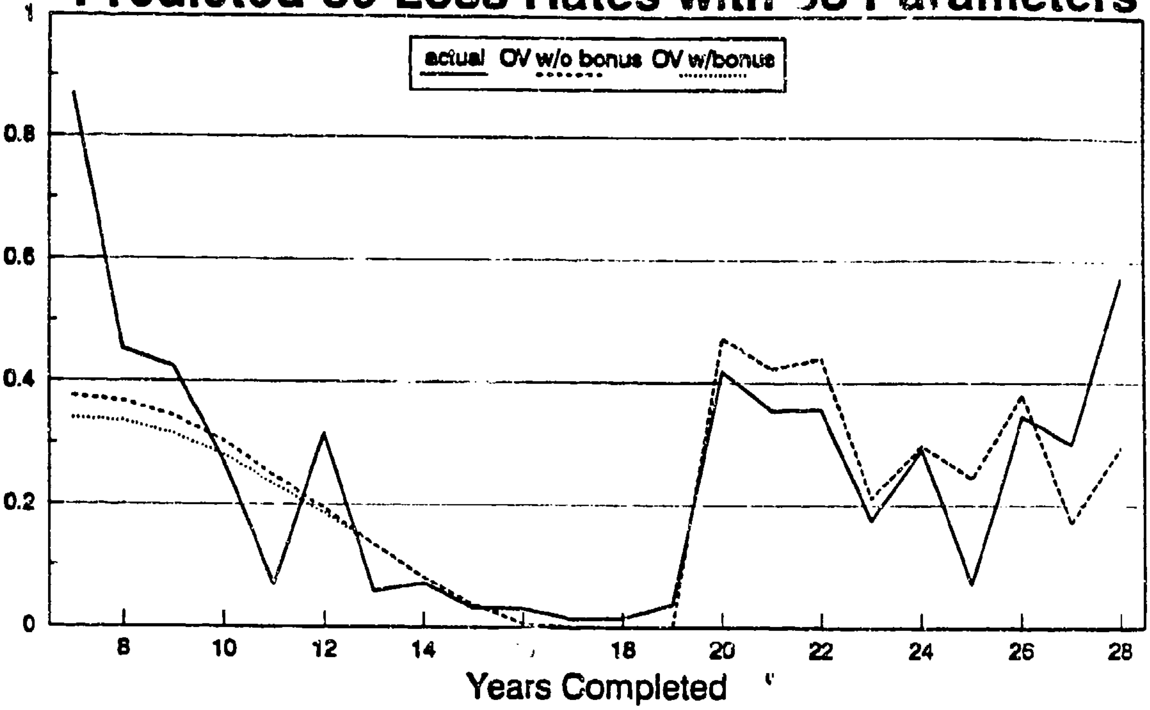


Figure 4.9
Predicted 89 Loss Rates with 38 Parameters



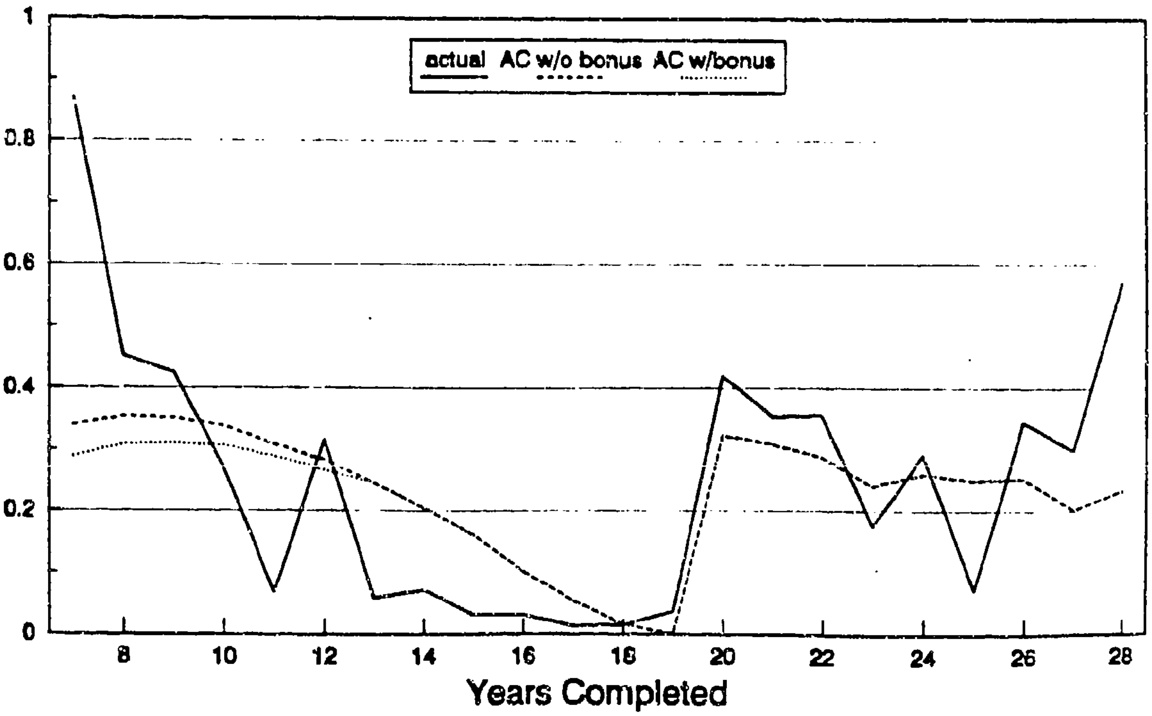


Figure 4.10
Predicted 89 Departures with 88 Parameters

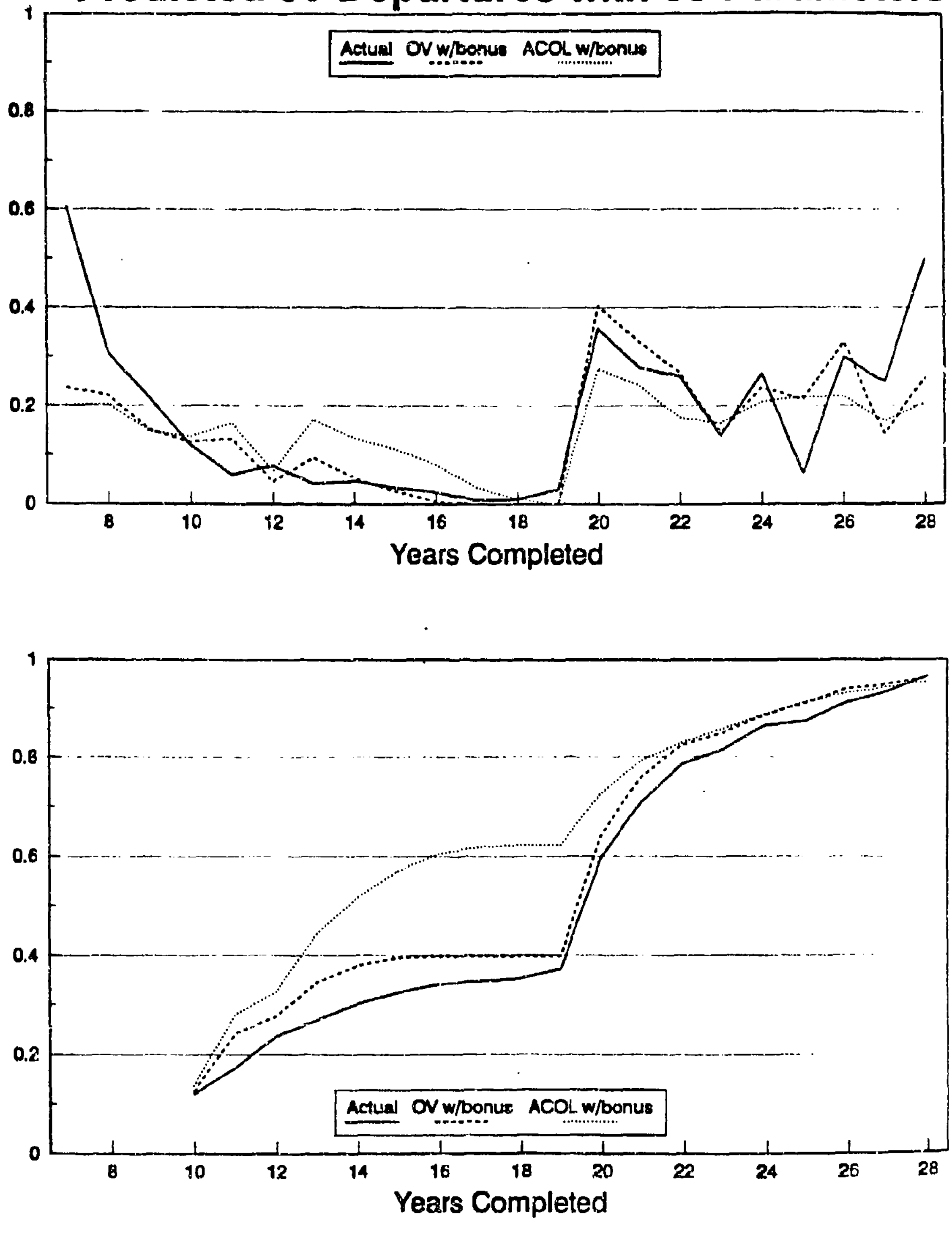
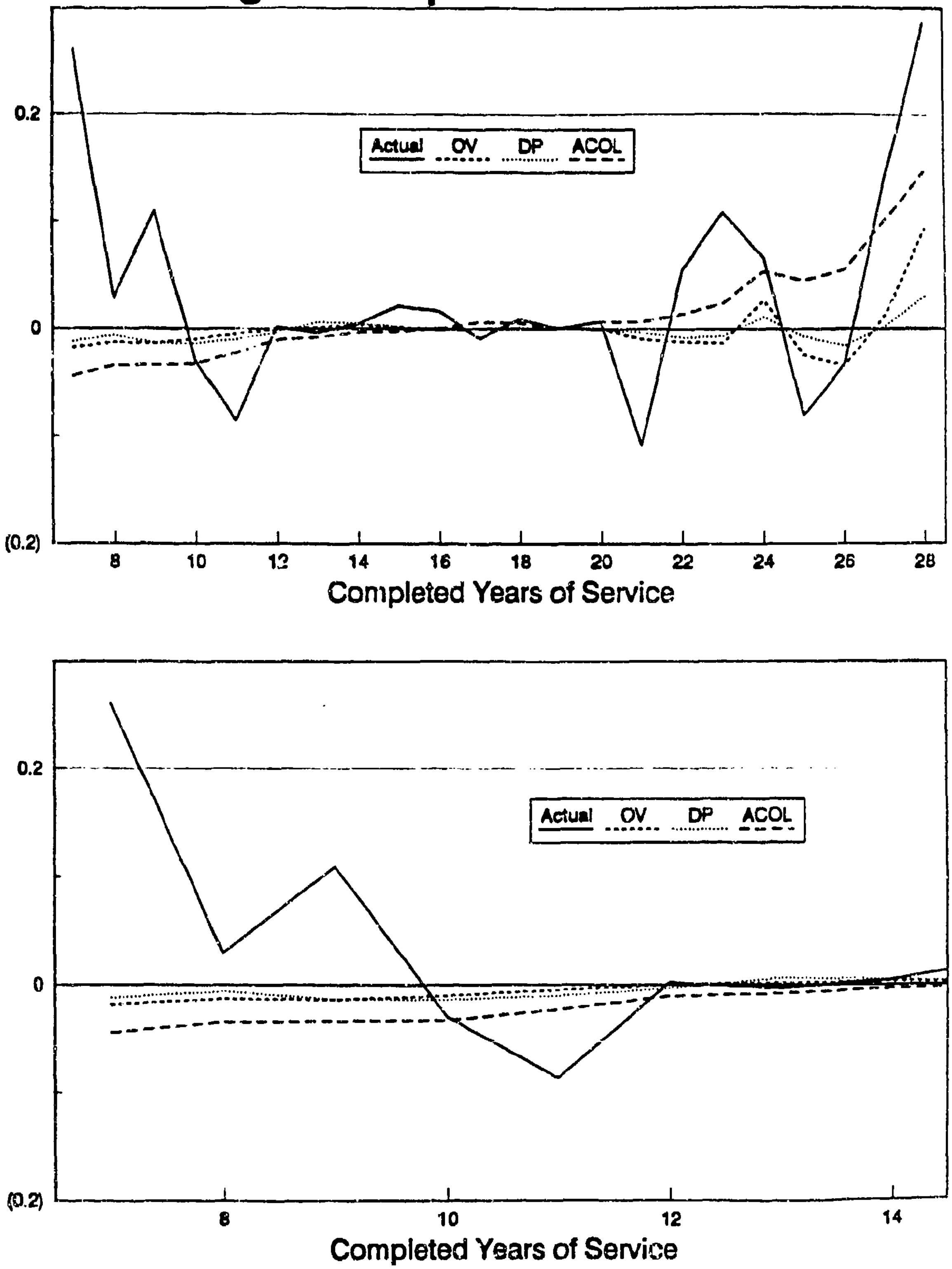


Figure 4.11
Changes in Departures: 1988 to 1989



departure rates for those completing 9 years of service increased over 0.1 from 1988 to 1989, and this is indicated by a positive 0.1 at 9 years of service.

The figure clearly shows the disappointing actual effects of the pilot bonus for those in this sample completing 7 through 10 years of service, where departure rates increased. All three models predict decreases in departure rates for those from 7 to 13 years of service, but the decreases for the option value and dynamic programming models are smaller than those predicted by the ACOL model.

4.3 Predicted Effects of ACP in 1988

A policy maker in 1988 considering the 1989 implementation of Aviator Continuation Pay would be interested in the potential number of pilots prevented from leaving the Air Force if the bonus were available. If the replacement costs saved because of improved retention outweigh the costs of the bonus program, the bonus is worth introducing. Since estimates of replacement costs for an experienced pilot range from $2 million for a young (7 years of service) to $14.5 million for a more senior pilot, small changes in retention may reap large savings.[11]

The top panel of Figure 4.12 compares the predicted changes in departure rates if the bonus program were offered to pilots in 1988. The lines represent departure rates with the bonus minus departure rates without the bonus, so negative values indicate a

[11]These replacement costs are from the DoD Aviator Retention Study, and are based on the so-called Full Replacement Cost (FRC) model. The FRC model takes into account the fact that to produce a replacement pilot, more than one person will have to be recruited and trained because of attrition rates in pilot training.

decrease in loss rates (an improvement in retention) as in Figure 4.11. From 7 to 10 years of completed service, both the option value model and the dynamic programming model predict less optimistic improvements in retention than the ACOL model, and the option value model continues to predict less improvement for the next two years as well. From 10 to 12 years, the dynamic programming model shows a larger decrease in departure rates because of the introduction of ACP. Both the option value and ACOL models show a gradual decline in the effect of the bonus as its value decreases, but the dynamic programming model indicates that after 9 years of service the bonus becomes more attractive for some reason.

The bottom panel of Figure 4.12 shows the potential numbers of pilots retained because of the implementation of ACP if the departure rate changes in the sample of MAC and SAC pilots are representative of the changes that would occur in the entire Air Force population. The figures in this graph ar based on the total number of pilots in the Air Force in 1988.[12]

The option value model saves 88 pilots among those with between 7 and 13 years of service, the dynamic programming model saves 89 pilots, and the ACOL model saves 126.

It is important to remember at this point that a policy analyst using the ACOL

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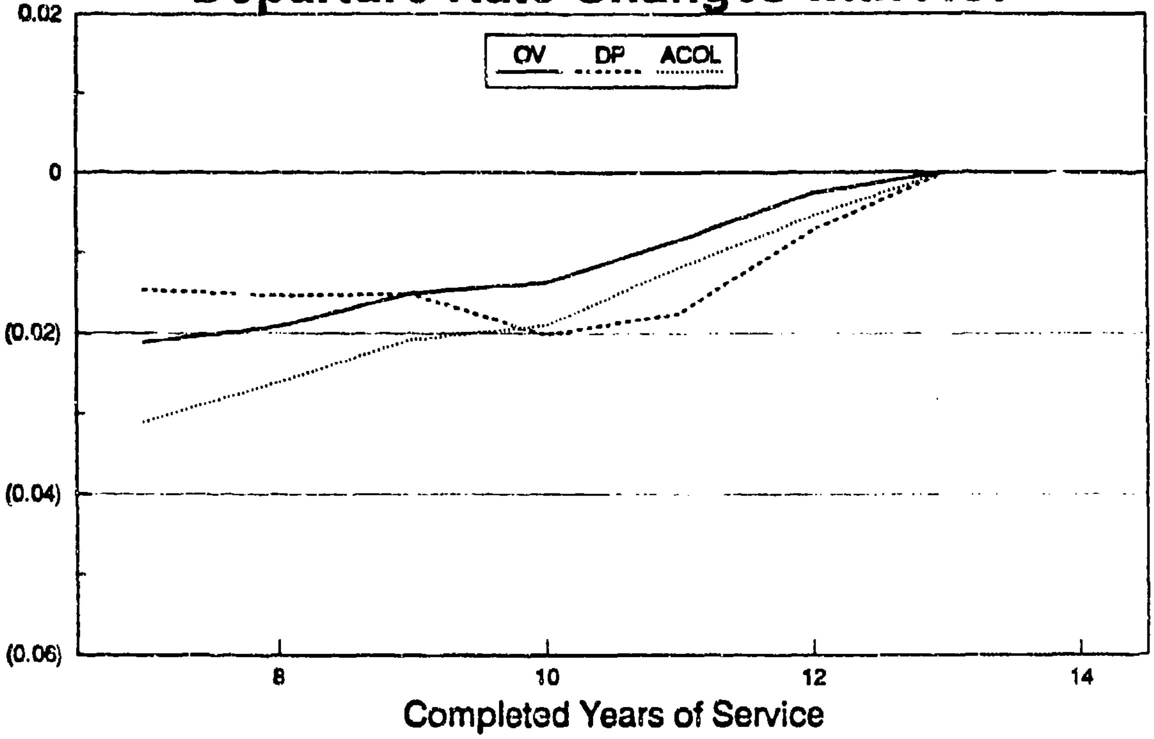
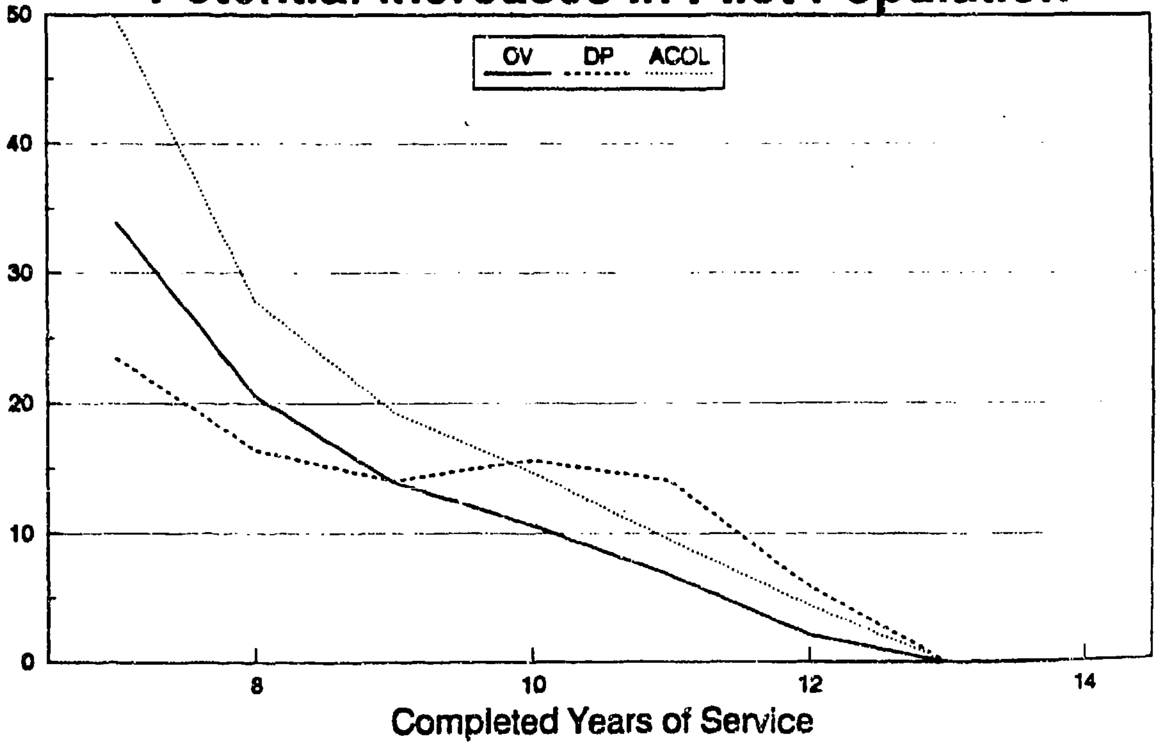
[12]This is from Bowman's data [9]. This information indicates only whether or not an officer is rated; it therefore includes some helicopter pilots, who were not eligible for the bonus. As a result, the potential increases are slightly overestimated. Since helicopter pilots in the 7-14 years of service cohorts represent less than 4% of the total pilot population, Figure 4.12 still gives a reasonable estimate of the differences in predicted changes of the three models.

Figure 4.12

Departure Rate Changes with ACP



Potential Increases in Pilot Population



model to estimate the potential number pilots retained because of the bonus would consider the numbers a lower limit, because the ACOL model is biased in such a way as to underpredict the effects of changes in compensation.

Conclusion

In this chapter, we have examined the out-of-sample predictive performance of three models of departure behavior. When model parameters estimated for MAC and SAC pilots are used to predict the departure behavior of TAC pilots, the predictions of the option value model and the dynamic programming model are quite good, and both are much better than the predictions of the ACOL model.

When the 1989 introduction of Aviator Continuation Pay is used as a natural experiment to test the ability of the models to predict changes in behavior because of increases in compensation, the results are somewhat ambiguous because the pilot bonus did not produce the anticipated improvements in retention. Air Force wide, departure rates for pilots actually increased for the population targeted for the bonus. In the sample of MAC and SAC pilots, some departure rates decreased, but most increased. All three models of behavior, as expected, predicted decreases in departure rates for the cohorts eligible for the bonus. The option value and dynamic programming models can be considered "better" than the ACOL model in the sense that they predicted a much smaller change in departure behavior than the ACOL model did, and the statistical measures of fit for them were also better.

The potential increases in the pilot cohort populations predicted by the different models when ACP is introduced for the 1988 sample may not appear significant. However, one of the goals of changes in pilot compensation is to eliminate a predicted shortage of pilots in Fiscal Year 1994, and comparatively small differences in annual departure rates can have a significant cumulative effect. In addition, some measures of replacement costs for Air Force pilots, such as the Full Replacement Cost model used in the DoD Aviator Retention Study estimate that to replace a pilot who leaves after 7 years of service, the Air Force must invest over $2 million. Thus, the 15 pilot difference between the option value model and the ACOL model predictions for the 7 years of service cohort could very well influence a decision to implement ACP based on cost-benefit analysis.

The original legislation for ACP authorized it only for pilots who accepted it in 1989, and as the expiration date for the legislation approached, other special compensation packages were proposed to help reduce pilot shortages.[13] Several of these were studied by the Congressional Budget Office using analysis based on parameters from ACOL models. In the next chapter, we will look at some of these proposals, and compare their predicted effectiveness based on the option value model to the predictions of the CBO.

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[13]The Aviation Career Improvement Act, sponsored by Sen John Glenn, was eventually passed in November 1989. It authorized continued ACP payments (with the new option of receiving half of the present value of the bonus as a lump sum payment) and introduced increases in monthly Aviation Career Incentive Pay.

CHAPTER FIVE

ALTERNATIVE PILOT COMPENSATION PLANS

In Chapter Four, we saw that the option value model provides a better fit for departure patterns than the ACOL model in two out-of-sample tests, one with a sample of Tactical Air Command pilots and one predicting changes that resulted from the 1989 introduction of Aviator Continuation Pay. The predicted retention effects of the bonus with the option value model suggest that pilots may not be as sensitive to substantial increases in pay as was hoped when ACP was approved. This fact is important in the evaluation of other proposed monetary incentives for improving pilot retention, and this chapter will compare option value predictions of the effects of some alternative compensation plans proposed at the end of 1989 to the predictions of the Congressional Budget Office. The information on history and proposed alternatives discussed below is from the 1989 CBO report, Alternative Compensation Plans for Improving Retention of Air Force Pilots.

5.1 Background

The authorization for payment of Aviator Continuation Pay expired at the end of 1989. According to the Congressional Budget Office, it was enacted as a temporary measure to allow the Department of Defense time to review the problem of pilot shortages and come up with a long-term proposal to solve it. ACP was meant to be an interim solution to the problem of pilot retention, not a permanent one ([12], p. ix).

Monetary incentives are not the only means available to reduce the anticipated 1994 pilot shortage. A reduction in the need for pilots is also possible. The CBO notes that there are three types of pilot positions:

a) "specific" positions, which require a pilot with skills for a particular aircraft

b) "generalist" positions, which require a pilot, but do not involve flying duties (such as pilots in research and development staff positions)

c) "rated supplement" positions, which do not require a pilot, but allow pilots to broaden their management skills and may benefit from the influence of a pilot's perspective (such as some Congressional liaison positions).

Table 5.1 shows the anticipated changes in inventory and requirements by type of pilot position.

TABLE 5.1

Pilot Shortages by Type of Position

	1989	1994
Projected Inventory	22,295	19,202
Projected Requirements	22,678	22,122
Flying	19,681	19,129
Non-flying		
Generalist	1,110	1,121
Rated Supplement	1,887	1,872
Projected Shortage	383	2,920

The Air Force could reduce its projected shortage in 1994 by more than half simply by eliminating rated supplement positions. Air Force personnel managers periodically review the number of rated supplement positions and have in the past reduced the number of pilots serving in them, but the Air Force does not want to eliminate them entirely because, in addition to the potential career benefits for pilots, the rated supplement positions provide a pool of pilots to return to flying positions in the event of conflict.

We have seen in the departure rate graphs of previous chapters that departure rates vary by years of service. Expected pilot shortages in 1994 also vary for different year-of service cohorts and, as shown in Table 5.2, they differ by type of aircraft.

TABLE 5.2

Air Force Estimates of Pilot Shortages by Type of Aircraft

Type of Aircraft	1989	1994
Fighter	1	691
Bomber	121	345
Tanker	176	782
Strategic Airlift	449	932
Tactical Airlift	-3[a]	355
Helicopter	-307	-199
Trainer	-54	14

a. Minus sign denotes an excess of pilots

NOTE: Estimated shortages of fighter pilots reflect the Air Force's decision to limit the number of fighter pilots in the rated supplement positions and not assign fighter pilots to generalist positions

As noted in the table, the shortages for fighter aircraft take into account the fact that the Air Force has decided to limit the number of fighter pilots who are assigned to non-flying positions. If this were not the case, and the non-flying jobs were distributed among all of the pilot categories, the fighter shortage would increase (some needed to fly would be placed instead in generalist or pilot supplement positions) and the shortages for other aircraft would decrease. Adjustments to the policy of assigning pilots to non-flying positions not only affect the size of projected shortages, but can also affect future departure rates. For example, if rated supplement positions are viewed as unattractive ones, pilots of non-fighter aircraft could come to resent the fact that fighter pilots are not required to fill them, and lowered morale among non-fighter groups could lead to higher departure rates in them.

Alternative Legislation

Because pilot shortages vary by type of aircraft as well as by years of service, and because the option exists to reduce pilot shortages by eliminating some non-flying positions for pilots, alternatives to ACP can address the pilot shortage by a variety of methods, ranging from directing pay increases only to those populations that will have large shortages to requiring the Air Force to reduce rated supplement requirements by allowing non-pilots to fill positions designated as rated supplement jobs. The CBO analyzed five possible forms of legislation that addressed the problem in different ways.

<u>Targeting of Bonus by Type of Aircraft</u>

One proposed bonus plan would direct pilot bonuses to the types of aircraft for which shortages will be the greatest by 1994. The size of the bonus would range from $6,000 per year to $12,000 per year as it does under the 1989 ACP plan, but the size would not depend on the number of years the pilot has served. Instead, it would vary depending on the type of aircraft flown, with higher bonuses going to pilots of aircraft experiencing the largest shortages. For example, following the shortages in Table 5.2, strategic airlift pilots would receive the largest bonuses of $12,000 per year, and trainer pilots would receive the lowest bonuses of $6,000 per year.

The Air Force has objected on equity grounds to this type of bonus payments targeting, claiming that morale of some pilot communities would suffer because of pay differences. However, as the CBO notes, there is precedent for such a bonus plan. Navy implementation of AOCP, for example, excluded pilots of non-fighter aircraft, and Air Force ACP is not paid to helicopter pilots.[1]

Doubling of ACIP and no Bonus

When ACIP was last increased in 1981, it amounted to a 21% "bonus" above the basic pay of a pilot with six years of service. From 1981 to 1988, basic pay and some allowances were adjusted for inflation, but ACIP was not. By 1988, the value of ACIP had decreased in real purchasing power by approximately 30%, and for a six year pilot was an amount approximately 17% of basic pay.

Doubling the amount of ACIP was another option to increase compensation for pilots. For a pilot with six years of service, for example, this would increase the amount

[1]The DoD Aviator Retention Study notes survey responses from pilots in non-targeted aircraft positions which say (essentially) "You may not have a shortage in this field now, but you will have one soon" because of the perceived unfairness of the pay differential.

received from $4800 per year to $9600. This increase would apply to all pilots, and in the Air Force view be more equitable, but it might be less efficient - pilots in aircraft categories that are projected to have large shortages in 1994 will receive the same incentive pay as those in aircraft with less severe shortages.

Senate Committee Plan

Senators John Glenn and John McCain proposed, and the Senate Committee on Armed Services approved, a plan that includes continuation of the original Aviator Continuation Pay as well as selective increases in the rates of Aviation Career Incentive Pay depending on the pilot's year group as shown in Table 5.3.

TABLE 5.3

Glenn-McCain Increases in ACIP

Years of Service	Pre-1990 ACIP ($)	1990 ACIP ($)
6 - 18	4,800	7,800
18 - 20	4,440	7,020
20 - 22	4,080	5,940
22 - 24	3,720	4,620
24 - 25	3,360	4,620

The criteria to continue receipt of ACIP under this plan also would change, by increasing the amount of cockpit experience required at the fifteen and eighteen year points in a pilot's career. ACIP amounts also would be increased in the future according to a formula based on basic military pay increases.[2]

In addition to the pay incentives, the original Glenn-McCain bill proposed reducing by 5% the number of non-flying positions that would be filled by pilots.

Modified Senate Committee Plan

This plan is the same as the Glenn-McCain plan except that in addition to varying the bonus by year, it also varies the bonus by aircraft. Table 5.4 shows the range of bonus amounts.

TABLE 5.4

Range of Bonus Payments in Modified Senate Plan

Years of Service	Strategic Airlift	Trainer
8	12,000	6,000
9	11,000	5,500
10	11,000	5,500
11	9,500	4,500
12	8,000	4,000
13	6,000	3,000

[2]A version of the Glenn-McCain proposal was passed in 1989.

Pilots of Strategic Airlift aircraft, the group expecting the largest shortage in 1994, receive the largest ACP payment, and trainer pilots receive the lowest, as with the first targeting by aircraft plan mentioned above.

House Committee Plan

This plan is the same as the Senate Committee plan, except that ACIP payments are not indexed to increases in basic military pay, and so the effects of the increase will be eroded by inflation.

5.2 CBO Analysis of Alternative Plans

Congressional Budget Office analysis of the five plans was based on the elasticity of continuation rates with respect to military pay. This approach is used frequently in Department of Defense analyses, and it starts with the ACOL model in the following way.

If we let D represent the probability of departing the Air Force (or the departure rate) and C the probability that an individual will continue service (the continuation rate), the ACOL model gives us

$$D = \frac{e^{-\alpha_0 - \alpha_1 ACOL}}{1 + e^{-\alpha_0 - \alpha_1 ACOL}} \quad and \quad C = \frac{1}{1 + e^{-\alpha_0 - \alpha_1 ACOL}} . \tag{5.1}$$

The elasticity of the departure rate with respect to military pay is given by

$$\epsilon_{D,M} = \frac{dD}{D}\frac{M}{dM} = \frac{dD}{d(ACOL)}\frac{d(ACOL)}{dM}\frac{M}{ACOL} \tag{5.2}$$

$$= -\alpha_1(1-D)\frac{d(ACOL)}{dM}M. \tag{5.3}$$

where M is military pay.

Similarly, the elasticity of the continuation rate with respect to military pay is

$$\epsilon_{C,M} = \alpha_1(1-C)\frac{d(ACOL)}{dM}M. \tag{5.4}$$

In using the ACOL model, the annualized cost of leaving is calculated for all of the potential departure years an individual has, and the maximum value is used as the independent variable in the logit relationship. This cost of leaving is the result of the decision to leave in a certain year. If we suppose that the military increases compensation in such a way that the year in which the maximum ACOL occurs does not change, then the derivative of the continuation rate with respect to ACOL has meaning only in that year. For other years - the ones not used in the logit equation - the derivative is zero, as is the derivative of ACOL with respect to military pay, (dACOL)/dM. The only value that matters is the maximum ACOL, and since it is calculated as an annual amount foregone if an individual leaves, its change will be approximately the same as the change in military pay.[3] Thus, the elasticities can be written

$$\epsilon_{D,M} = -\alpha_1(1-D)M \quad , \quad \epsilon_{C,M} = \alpha_1(1-C)M \quad . \tag{5.5}$$

For a given cohort, the elasticity is calculated using the departure or continuation rate of the cohort and the mean income of a member of the cohort. The second relationship in (5.5) is what the CBO used, but only indirectly. Because Air Force pilot elasticities by years of service were not available, the CBO study used a set of elasticities from Navy data on the continuation behavior of jet, propeller, and helicopter pilots, the numbers being .313, .294, and .147 respectively.[4]

To begin with, the CBO constructed a base case predicted 1994 inventory based on projected 1989 continuation rates and inventories. Then, for each years-of-service cohort, the percentage increase in pay under a given compensation plan was calculated.

[3]If the pay increase is the same in all years, as is the case with ACP, (dACOL/dM) = 1. If pay increases are made in a different way (for example, a certain percentage increase each year), then equation 5.5 is only an approximation. Hogan and Goon write

$$\epsilon_{C,M} = \epsilon_{C,ACOL}\,\epsilon_{ACOL,M} = \alpha_1(1-C)(ACOL)\epsilon_{ACOL,M}$$

and apparently calculate the elasticity of ACOL with respect to military pay based on ACOL values after a 10% increase in military pay, using this value to calculate $\epsilon_{C,M}$.

[4]Use of these values ignores the fact that elasticities vary by the retention rate of different cohorts. Reported elasticities vary wildly. Hogan and Goon estimate an elasticity of 1.91 for pilots with 7 years of service who are Air Force Academy graduates, the DOPMS (Defense Officer Personnel Management System) uses an elasticity of 2.6 for the same group. To quote Hogan, "The comparison is indicative of the sensitivity of the pay elasticity to the specification of the earnings function, and the difficulty in sorting out the channels of influence of personal characteristics on retention." ([26], p.83)

Using the pay elasticity for the given pilot community, the percentage change in continuation rate for the cohort (%ΔC) was obtained, and the new continuation rate, NC, given by

$$NC_{tj} = C_{tj} + \%\Delta C_{tj} ,$$

where t is the year and j is the years of service cohort.[5]

The new continuation rates were applied to the 1989 inventory of pilots in order to create the new 1994 inventory under the alternate compensation plan.

In the compensation plans proposed, the CBO assumed that acceptance of an increase in pay carried with it an additional service obligation, as the 1989 Aviator Continuation Pay did. If a pilot completing 7 years of service accepts ACP, for example, his or her continuation rate will be 100% for each year through 14 years of service. In the inventory adjustments with the improved continuation rates, it is important not to "double count" increases in the pilot population.

This is easily avoided. In year t-1 for the j-1 years of service cohort, calculate the number of pilots who would remain under current compensation, $INV_{B,t-1,j-1}$ and the number who would remain with the alternative pay plan, $INV_{A,t-1,j-1}$. The difference is the number who take the new bonus, $TAKE_{t-1,j-1}$. In year t and cohort j, the number of pilots under a commitment at the beginning of the year is $TAKE_{t-1,j-1}$. For the remaining pilots without a commitment, calculate the number who would remain under the old

[5]Note that this year-by-year adjustment of continuation rates does not take into account the fact that an individual deciding to accept increased compensation also forfeits the option to leave for several years. In effect it reduces the decision to remain to a consideration of compensation in one year, instead of considering changes in a stream of future income.

system and the number who would remain under the new system. The total inventory at the end of year t is the number who would remain under the new system plus the number who are already under a commitment, and we also now have more pilots who are committed to remain in the service. Write this as

$$INV_{Atj} = (INV_{At-1,j-1} - TAKE_{t-1,j-1}) \times NC_{t-1,j-1} + TAKE_{t-1,j-1}$$

where

$$TAKE_{t-1,j-1} = INV_{At-1,j-1} - INV_{Bt-1,j-1}.$$

To get the 1994 total inventory under the new compensation plan, CBO added over all years of service, and the result was compared to the base case inventory to determine the improvement in retention.

5.3 Comparing Predictions of ACOL and Option Value Models

The CBO report broke the pilot population into different aircraft types. Since the data used in this study allowed distinctions only by Air Force command, we will consider only those proposed compensation changes that affect all pilots equally - the proposal to double ACIP and the Senate plan. Since the House proposal is not significantly different from the Senate plan, it will also not be considered.

To get a feel for the differences in the predicted effects of the compensation changes analyzed in the CBO report if the option value model and ACOL model from Chapter Three are used, assume that the predicted changes for MAC and SAC pilots are representative of the improvements experienced by the pilot population as a whole. If we assume that the departure rates predicted by the option value model for 1988 hold through 1994 and use the pilot inventory from 1988 reported by MPC[6], the shortage of pilots in the 8 to 19 year groups is 3000 - not significantly different from the DoD forecast of 2900, so this approach seems reasonable.[7]

With this assumption, the predicted 1994 inventories under the double ACIP and Senate plans were calculated in the same way as the CBO inventories[8]. The results these calculations are in Table 5.5. In addition to the two CBO plans, the table includes the 1994 inventory if the 1989 ACP was continued in the same form, and also the effects of a $21,000 annual bonus for pilots in the 8 to 13 year cohorts.

The Table shows the pilots that would be added under the different compensation plans in the 8 to 13 year groups, which are reported explicitly in the CBO report, and the 8 to 19 year groups, in which the 1994 shortage is expected. The numbers for 1990 and 1994 represent the number of "fence-sitters" who accept the bonus in those years, and the totals for 1990 -1994 are those who would have left without the new

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[6]There are slight differences (up to a few hundred) in the number of pilots in the inventory as reported by the DoD Aviator Retention Study, the CBO report, and the data from MPC. This is probably the result of data gathering at different times of the year.

[7]With the ACOL values, the predicted shortage in 1994 is just over 3570, because of the overprediction of departure rates above 13 years of service. This difference seems close enough to use the predicted changes with the ACOL model as a general indicator of the effects of changes in compensation.

[8]The CBO report also assumed that pilot production would remain at the 1988 levels of 1625 per year. This was incorporated in the option value inventories by assuming that the number of pilots in the 7th year of service (the end of the commitment for pilot training) was 1625 for each year.

compensation, but remain because of it. The numbers do not show the total number of pilots who would be receiving the new compensation, because many who would have remained without it will be receiving it also (at no "cost"). For the CBO analyses, the added pilots from 8 to 19 years are the difference between the 2920 shortage noted in Table 5.1 and the shortage indicated by the new inventory reported in Appendix B of the CBO report.[9]

The results for Aviator Continuation Pay show the long term effects of the differences in ACOL and option value predictions that we observed in Chapter Four. According to the DoD Aviator Retention Study, the introduction of ACP was supposed to reduce the 1994 shortage by 50%; ACOL predictions reduce the shortage by 19%, and option value predictions show a reduction of only 14%.

The extremely large differences among the three models for added pilots under the double ACIP and Senate plans were entirely unexpected. It is possible that with the added information of changes by type of aircraft flown the number of pilots added under the option value and ACOL models would increase, but it is more likely that the primary reason for the differences is the CBO's application of one elasticity of the continuation rate to all cohorts, and the use of an elasticity calculated for an entirely different Navy population.

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[9]CBO predicted 1994 inventory for the double ACIP plan is 21,067; for the Senate plan it is 21,545.

TABLE 5.5

Projected Improvements in Retention for 1990-1994

		Added Pilots 8-13 Year Groups			Added Pilots 8-19 Year Groups		
Plan	Model	90	94	90-94	90	94	90-94
ACP	ACOL	126	115	492	126	115	562
	OV	91	81	357	91	81	412
Double ACIP	CBO	133	108	-	-	-	1865
	ACOL	95	90	331	129	111	529
	OV	60	57	212	71	65	316
Senate Plan	CBO	360	308	-	-	-	2343
	ACOL	183	173	696	206	187	891
	OV	128	110	495	137	122	613
$21,000/Year	ACOL	250	246	940	250	246	1116
	OV	186	179	719	186	174	850

The DoD Aviator Retention Study notes that a $21,000 per year bonus might be necessary for some cohorts in order to completely eliminate the 1994 pilot shortage, and that an increase of ACP to this level would be considered depending on the results of the 1989 program. The report does not say which cohorts should receive this amount, so the inventory change in Table 5.5 is based on the assumption that all pilots eligible for the 1989 ACP bonus would receive $21,000 per year until completing their fourteenth year of service. Even with this very large bonus (which represents a 56% increase in pay for a pilot with seven years of service), the ACOL model predicts a decrease in the shortage of 38%, and the option value model is far less optimistic with a prediction of only a 29% decrease.

Over the five-year period, the ACOL model predicts that 31% more pilots will be retained with the $21,000 annual bonus than the option value model does.

Conclusion

Many assumptions were made in the construction of Table 5.5, and it would be unwise to claim that any of the numbers are precise, but the magnitude of the differences in the predicted effects of various changes in compensation depending on the model used seems great enough to conclude that the effect of financial incentives on the retention of pilots has been largely overestimated. I. is, of course, easy to say this in light of the actual effects of the implementation of Aviator Continuation Pay, but a senator in 1989 contemplating the Glenn-McCain proposal - which might cost $586 million dollars over five years - would certainly think differently about the legislation if she expected to add less than a thousand pilots to the inventory, as indicated by the option value predictions, instead of over 2000 as the Congressional Budget Office predicted. This is especially true because much of the cost of such incentive programs comes from paying bonuses to pilots who are already inclined to stay, and so the average cost per pilot "saved" is extremely high.[10]

[10]Suppose, for example, that an incentive proposal was to give all pilots in the 7 year cohort (approximately 1300 pilots in 1988) a $12,000 bonus to stay, and that this increases the retention rate from 80% - 1040 pilots (about what it was) to 81% - 1053 pilots. The bonus costs over $12.6 million - almost a million dollars per extra pilot saved.

When considering financial incentives for pilots, the DoD Aviator Retention Study recognized that they were not the answer to the pilot shortage, and listed other options for improving retention, but also noted that immediate implementation of ACP would stem the loss initially. If option value predictions of the relatively small effect of increases in compensation had been available, the Department of Defense may have been inclined to press for legislation in other areas before pressing for increases in compensation.

CHAPTER SIX

PENSION SIMULATIONS

In the past three chapters, we have studied the performance of different models in predicting the departure behavior of Air Force pilots. The general conclusion so far is that the option value model does as well as the dynamic programming model (and perhaps a bit better), and far better than the simple form of the Annualized Cost of Leaving model. In Chapter Five, we saw that the differences in the option value and ACOL model, and analyses based on elasticities determined from ACOL models, lead to quite different predictions of the changes in behavior that would result from the introduction of a variety of pilot compensation plans.

The military pension system is a much more expensive component of military compensation than special incentive payments for pilots, and changes in its structure may save the government significant amounts of money, but if the effect of such changes is the departure of large numbers of personnel who no longer find it worthwhile to remain in the service until retirement, any savings will be canceled by increased costs in recruitment to replace those who leave. As pointed out in Chapter One, failure to consider the retention and personnel effects of changes in the retirement system was a major criticism the Fifth QRMC had of studies that had preceded it.

This chapter illustrates the usefulness of the option value model in predicting the effects of changes in retirement compensation on departure rates for Air Force pilots. Five changes, all similar to the types of recommendations made in the past by commissions that studied the military pension system, are analyzed using the option value model alone.[1] Finally, the option value predicted effects of the pension change implemented in 1986 are compared to the predicted effects using the ACOL model, and we will see that the differences have significant implications for military personnel planning.

6.1 Pension Change Simulations

The "base case" pension plan for comparison is the plan in effect for personnel who entered the service before September, 1980.

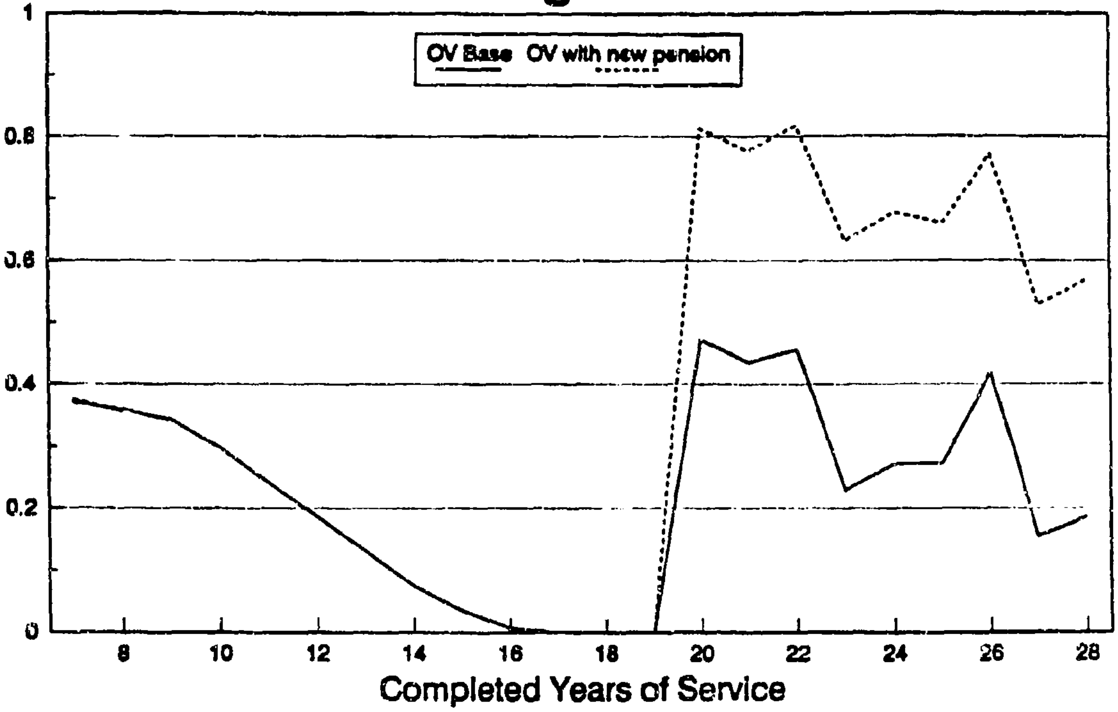
Plan 1: Pension determined at a flat 50% rate

This plan provides a pension of 50% of the individual's final basic pay regardless of the number of years of service at retirement. There are no other changes. This policy has the effect of penalizing people who remain longer than 20 years of service compared to the base case, because there is no increase in the pension calculation rate. However, the pension does increase with years of service because of increases in salary.

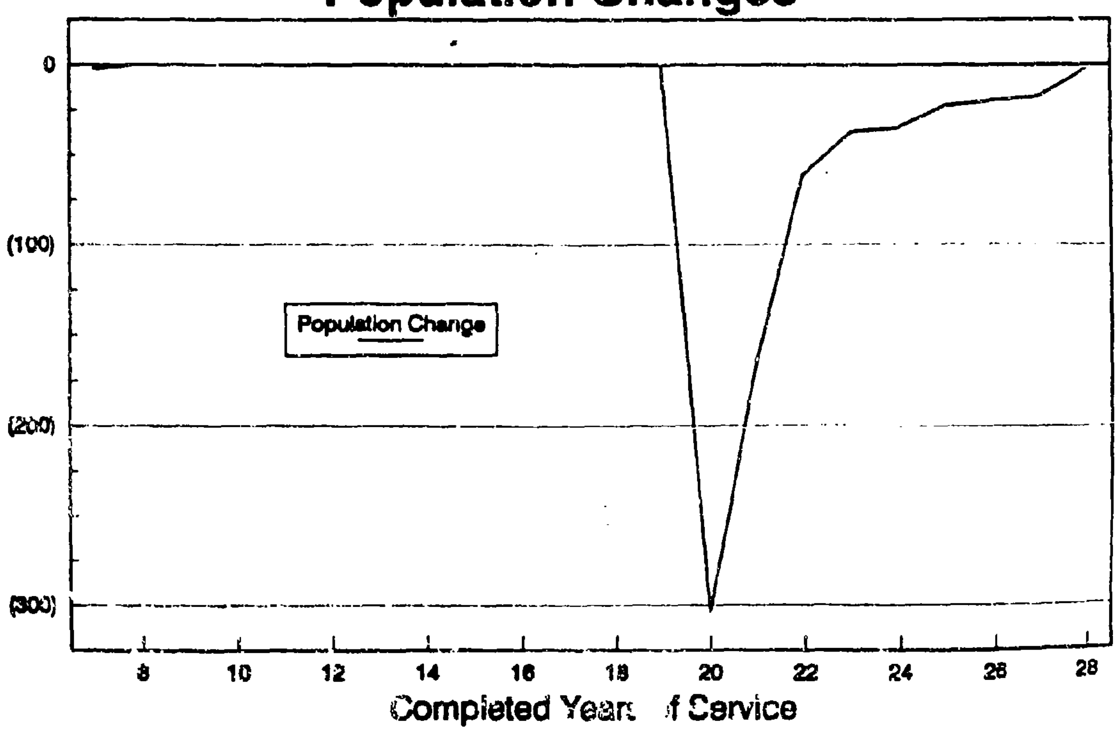
Figure 6.1 shows the effects of the flat rate. The top panel of the figure compares departure rates under the base case plan to those under the new plan. The bottom panel uses these changes to calculate the changes in the pilot population at

[1]This analysis parallels that of Argüden for enlisted personnel in [2].

Figure 6.1
Loss Rate Changes Under Plan 1



Population Changes



various years of service, with positive values indicating that more people remain in the service and negative values indicating more people leave.

As we would expect, the departure rate increases for those who have completed 20 years of service, since the motivation to remain longer has decreased. Departure rates for those with higher tenure increase for the same reason. Interestingly, this pension change has no effect on officers before the 20 year career point. This seems to indicate that the influence of the pension system for younger officers is confined to the value of the large jump at vesting, and since this has not changed, departure rates for younger officers don't either .[2]

The increased loss of just over 300 pilots after 20 years of service would have a significant effect on Air Force personnel policies, since it represents the departure of an extremely large number of those in upper level management positions.

Plan 2: Delay of Benefit Receipt

One of the criticisms of the current retirement system is that service members are able to retire at very young ages (as young as 37 in the case of enlisted personnel) and can sometimes end up receiving retirement benefits for longer periods than they were in the service. An answer to this criticism, and a way to reduce the present value of benefits paid to young retirees, is to delay the receipt of benefits until 30 years after entry into the service. An individual who retires after 20 years

[2]The ACOL model shows a very slight increase in departure rates from 7 to 12 years of service with the flat rate pension.

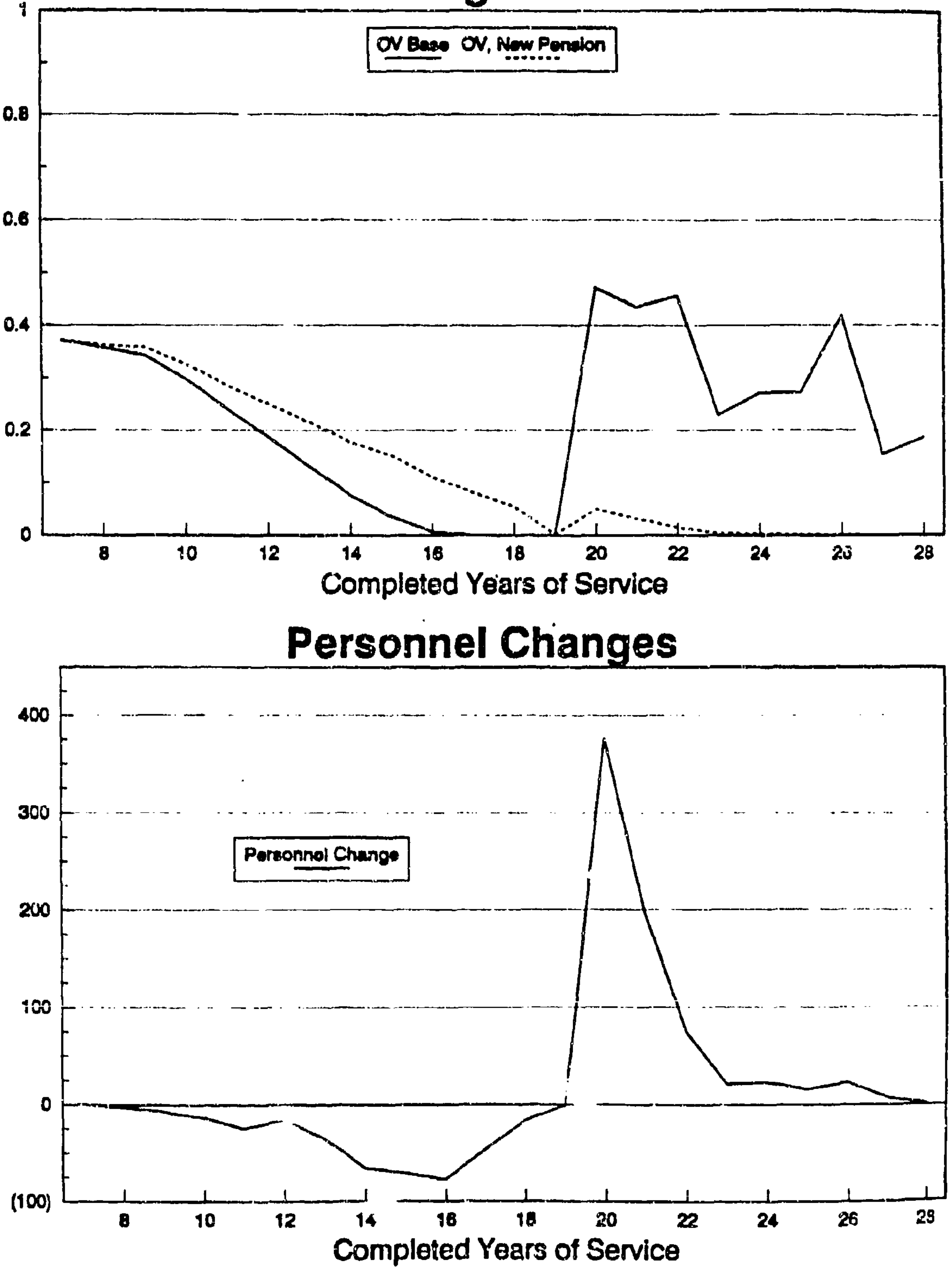
of service will still have earned a pension of 50% of basic pay, but will not start to receive it until the 30th anniversary of commissioning, though the annual amount will retain its real value because it will be adjusted for inflation from the twentieth to the thirtieth years. For people who retire after 30 years of service, this policy changes nothing.

This policy makes pension benefits less attractive for those in the early years of service because the delay in receipt of the pension reduces its present value. For those who are vested after 20 years of service, there is some added motivation to remain in the service to increase the percentage of basic pay that is used for the pension calculation.

The effects of this plan are shown in Figure 6.2. Departure rates increase from 7 to 19 years of service, with the increases quite large from 14 to 18 years. It is a little surprising that there is an increase in departures for those within two years of vesting. Apparently, the new ten year delay between vesting and receipt of pension payments makes it worthwhile to start in a civilian airline job as soon as possible - the rate of increase of airline salaries makes the extra year of civilian employment worth more than the annual pension benefit.

For those who have completed 20 years or more of service, the departure rates decline significantly. After vesting, there are three incentives to remain: the increase in the percentage of pay that is used for the pension calculation, the increase in base pay used in the calculation, and the increase in the present value of the

Figure 6.2
Loss Rate Changes Under Plan 2



stream of pension benefits because the time until receipt of benefits after 30 years of service is reduced.

The bottom panel of Figure 6.2 shows that a large number of pilots will decide to leave the Air Force before they are eligible for pension benefits. Once again, the loss of experienced pilots, this time in the 14 to 19 years of service cohorts, would present problems for filling senior leadership positions. However, the number of pilots who remain after 20 years of service increases substantially. The long term implications of these changes are that fewer people will make it to the 20 year point in a career, but once they are vested in the pension, they will tend to remain in the service longer.

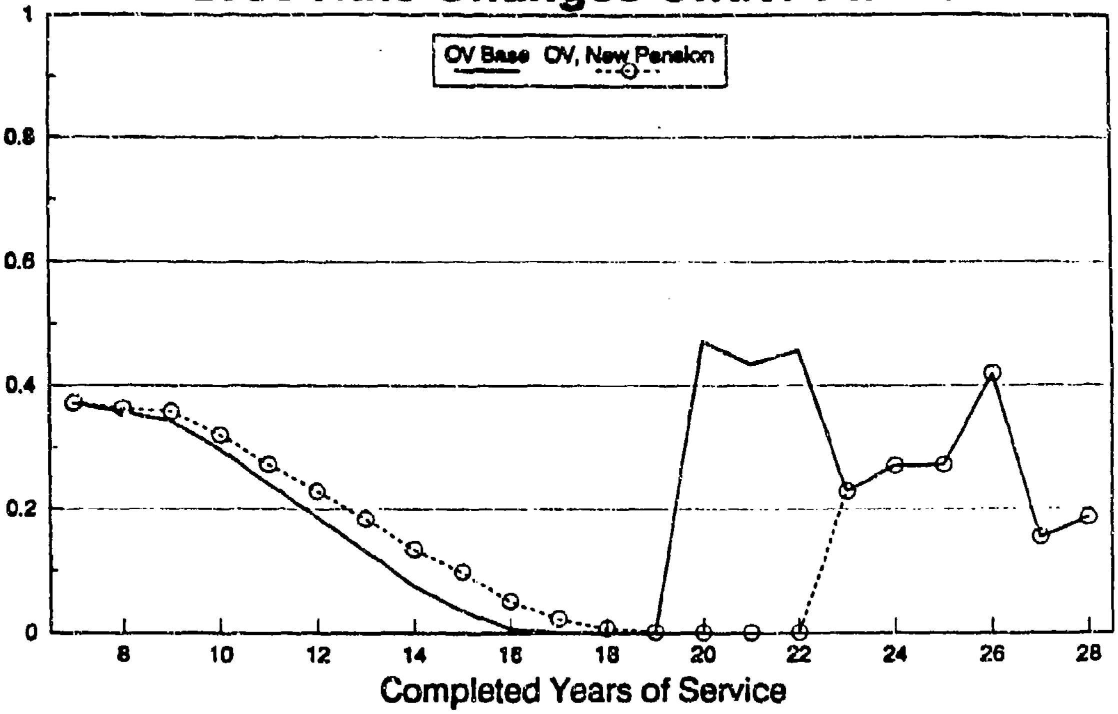
Plan 3: Change of Vesting Year

The current retirement plan fully vests the individual after 20 years of service. One change considered is to delay vesting until 23 years of service, but keep the calculation of the pension amount the same as the method used in the base case plan. People who leave before 23 years of service receive no pension; those who leave from 23 years to 30 years receive the same pension benefits as with the base case.

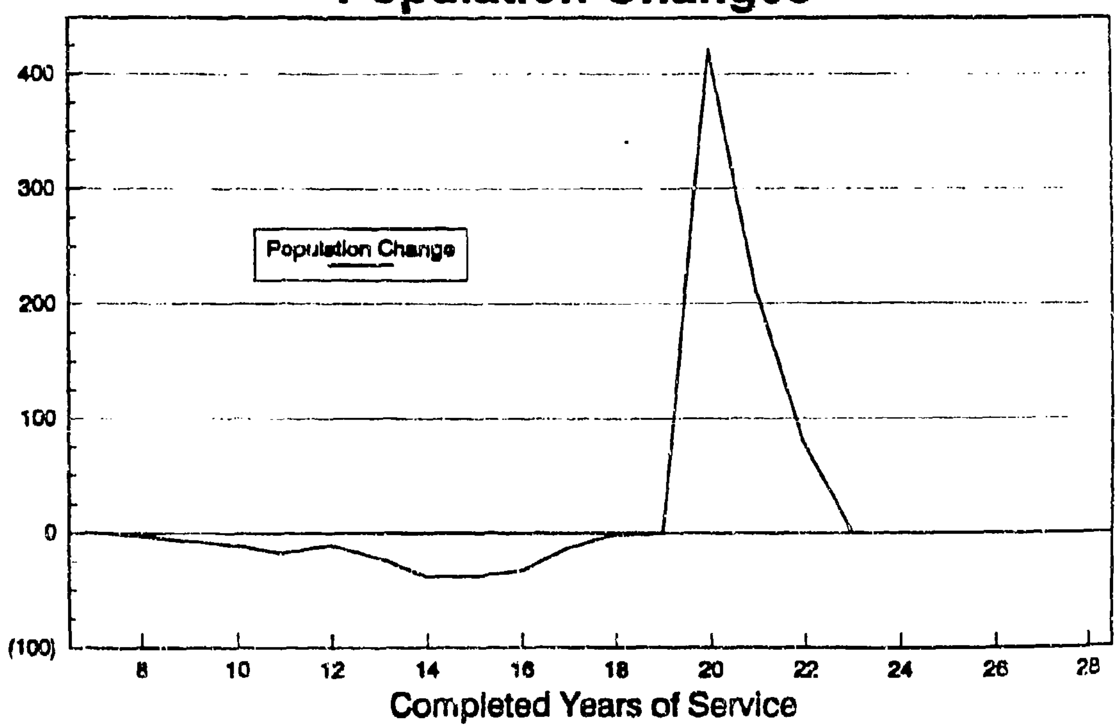
This change could cause people to leave the service at earlier dates because of the delay in receipt of pension benefits, but will encourage more people to remain in the service from 20 to 23 years of service in order to receive a pension.

Figure 6.3 confirms this intuition. The jump in departure rates moves from

Figure 6.3
Loss Rate Changes Under Plan 3



Population Changes



20 years of service to the new vesting year at 23. The delay in vesting results in more departures for younger officers, but since the pension is unchanged for those who remain after 23 years of service, there is no change in departure behavior for those cohorts.

The bottom panel of Figure 6.3 indicates that fewer pilots will leave because of the delay of benefits than would leave under Plan 2, and more would remain from 20 to 22 years of service.

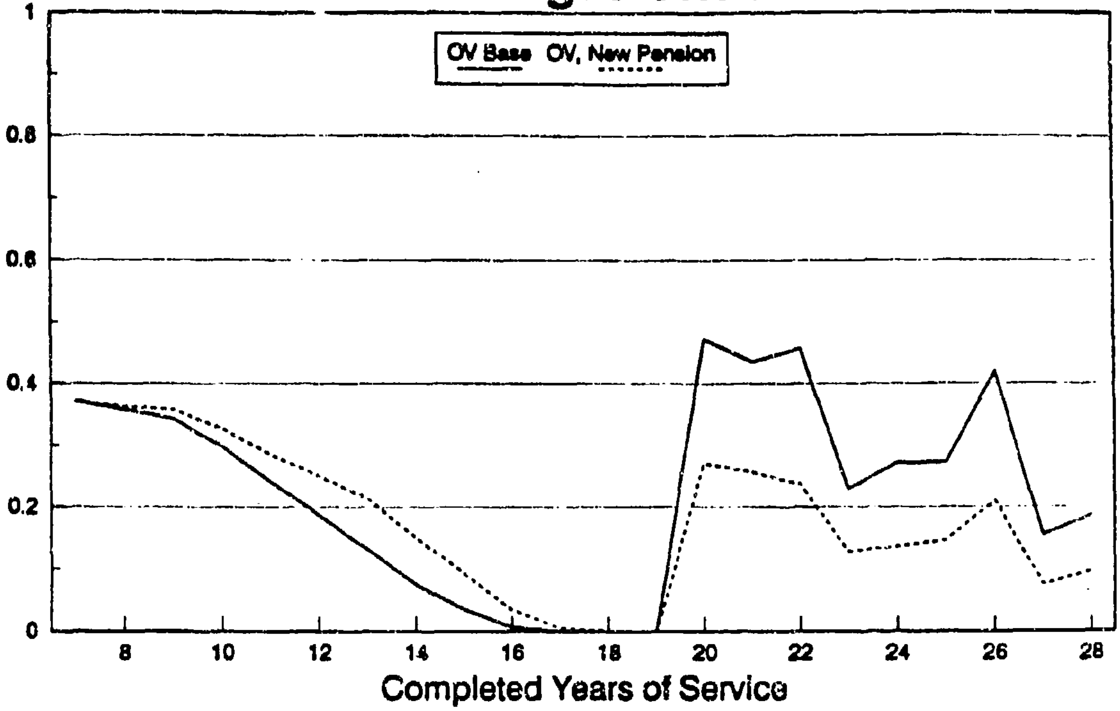
Plan 4: Penalty for Retirement Before 30 Years of Service

This plan assesses a 1% penalty for each year before 30 years of service that a person retires. Thus, someone who leaves after 20 years of service and would receive a pension of 50% of basic pay under the current system would receive only 40% under the new system; someone who retires after 25 years will receive 57.5% of basic pay instead of 62.5%. The effect of this plan is that the pension rate is 40% plus 3.5% times the years of service over 20. The maximum pension possible is still 75% of basic pay after 30 years of service.

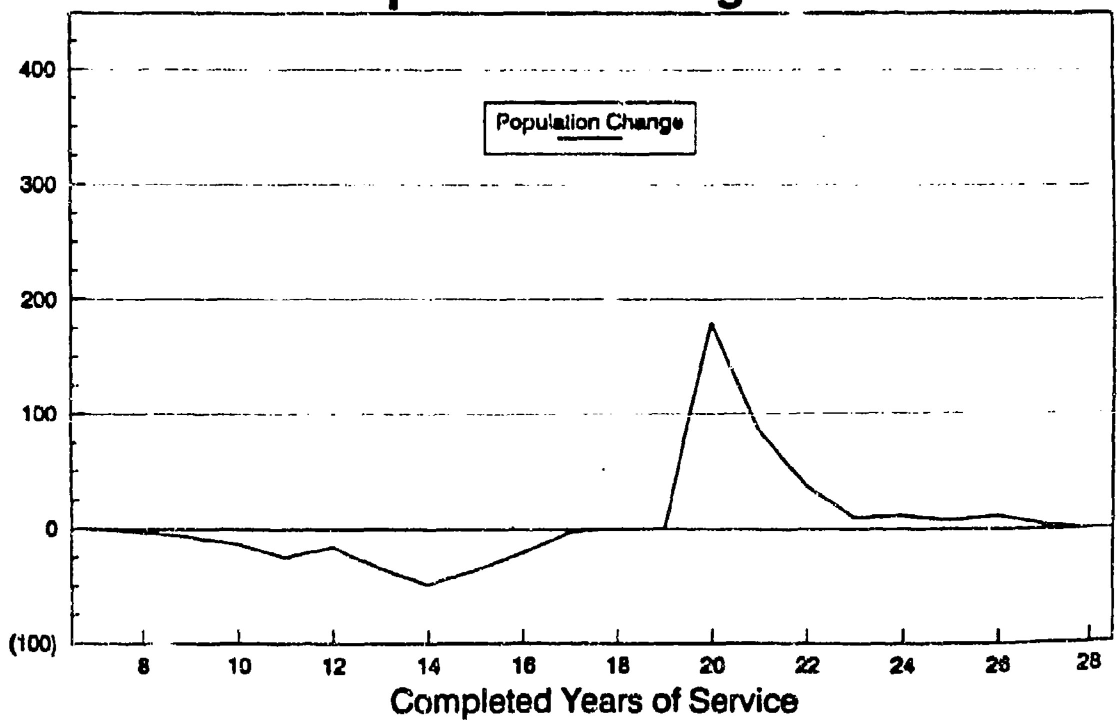
This plan reduces the value of retiring after 20 years of service, and provides incentive to remain past that time because the pension rate increases faster than under the base case plan. It also decreases the value of the pension for those individuals at early stages in their careers before vesting.

In Figure 6.4, we see that once again this plan will result in larger departure

Figure 6.4
Loss Rate Changes Under Plan 4



Population Changes



rates for those in the early stages of their careers because of the loss in pension value. Departures after 20 years of service decline, but not as dramatically as under plans 2 and 3, because an individual can still leave the service and begin receiving benefits immediately. Pilot losses before vesting are lower than under the previous plans, and so are the gains after vesting.

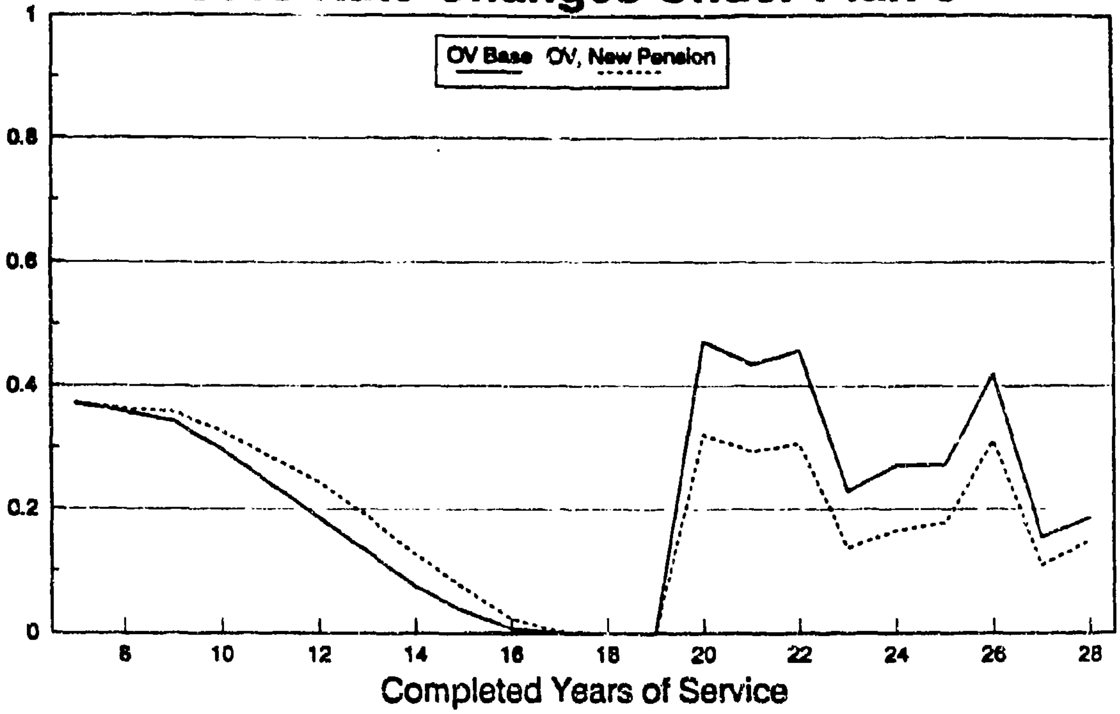
Plan 5: Penalty with Rate Restored 30 Years After Commissioning

Under this plan, the pension calculation is the same in Plan 4, but 30 years after commissioning the pension is restored to what it would have been under the base case plan. Thus, an individual who leaves after 20 years of service will immediately begin receiving a pension of 40% of basic pay, but ten years later the pension amount will be increased to 50% of the basic pay earned at retirement, with cost of living adjustments for inflation.

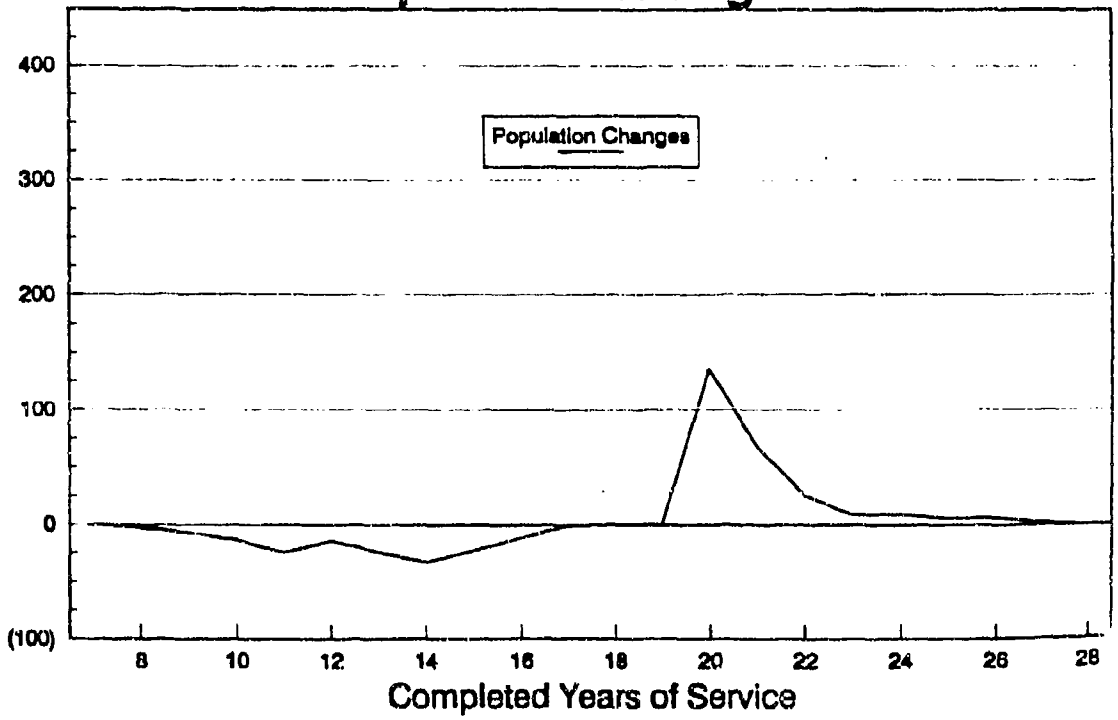
Once again, this plan lowers the incentive to remain in the military until vesting in the pension, but provides incentive to remain after 20 years of service in order to receive a higher pension calculation rate both immediately after retirement and 30 years after commissioning.

Figure 6.5 shows that the increased value of the pension under this plan compared to Plan 4 has only a small effect on officers before vesting. Departure rates are slightly lower than with Plan 4 because of the restoration of lost pension value thirty years after commissioning. This difference is not large, since for individuals at, say, twelve years of service the difference in the two plans will not

Figure 6.5
Loss Rate Changes Under Plan 5



Population Changes



be evident for almost two decades. What is slightly surprising is the change in departure rates after vesting. Whereas with Plan 4 there was incentive to remain beyond 20 years of service in order to receive a higher pension calculation rate, this incentive decreases under Plan 5 because the penalty incurred for retiring before 30 years of service will be eliminated in a few short years anyway. A person retiring after 20 years of service under plan 4 will receive 40% of base pay as a pension until death; the same person under Plan 5 will receive 40% of base pay for ten years, and then the pension will increase to 50% of the base pay at retirement with adjustments for inflation. The increase will make the penalty for retiring after 20 years less than under Plan 4, and so more people will be willing to depart. The difference is not that large, but is noticeable.

Plan 6: The 1986 Pension Change

As outlined in Table 1.1, this plan has three components. First, pension rate calculations incorporate the 1% penalty for retiring before 30 years of service, as in plans four and five, and base the calculation on the average of the highest three years of basic pay[3]. Second, it decreases the amount of protection from inflation by making annual pension adjustments at a rate 1% below the consumer price index. Third, when the retiree reaches the age of 62, there is a one-time adjustment so that

[3]Recall from Table 1.1 that individuals who entered the service between September 8, 1980 and July 31, 1986 have their pensions calculated based on the "high three" average. The observed effects of this change have been, and the predicted effects of it with the ACOL and option value models are, negligible. Because of this, calculations of pensions under plan 6 were done using the final pay of the individuals in the sample.

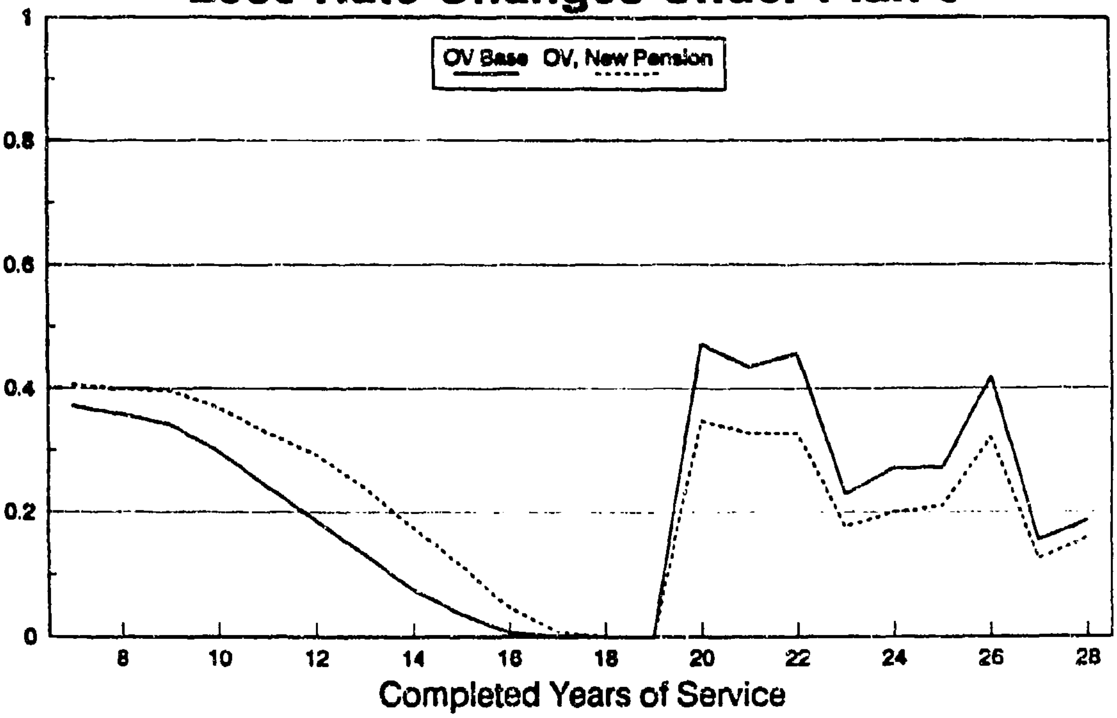
the annual pension payment has the same real value as if the individual had retired under the base case plan. After age 62, annual pension adjustments are made at 1% below the CPI again.

Unlike plans four and five, this plan effectively penalizes even those who remain in the service for a full 30-year career, because of the loss of inflation protection. The loss of cost of living protection further lowers the pension value perceived by younger officers who are not yet vested. Motivation to remain after vesting at 20 years of service continues as in plans four and five because of the annual increases in the percentage rate for the pension calculation, but the motivation is lower than in those plans because of the decrease in the cost of living adjustment.

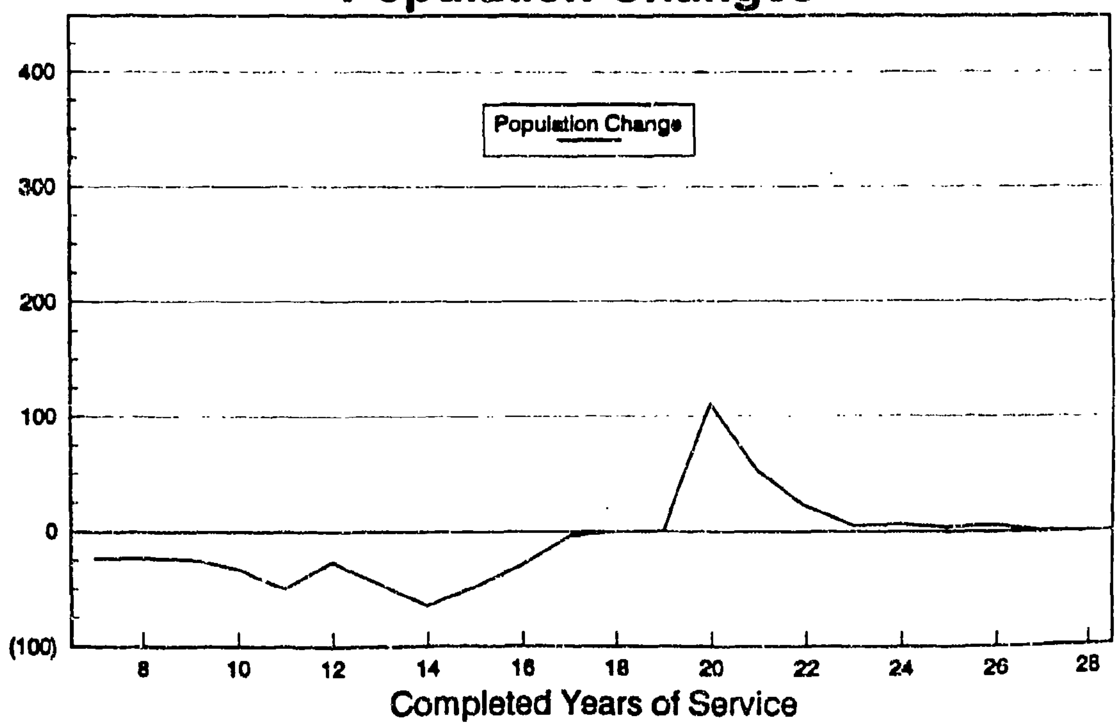
The effect of the double penalties (decreases in calculation rates and decreases in inflation protection) of this plan is fairly dramatic. Large increases in departure rates are observed even for pilots with 7 through 9 years of service, as shown in Figure 6.6. The incentive to remain after 20 years of service remains, as in plans 4 and 5, but the number of pilots who decide to remain is slightly smaller than with Plan 5 and a little over half of those who decide to remain with Plan 4.

The restoration of the pension to base case levels after the retiree reaches age 62 does not make up for the loss of pension value that results from decreased inflation protection. As a comparison with Figure 6.4 shows, a permanent reduction of the pension calculation rate but with full inflation protection is valued more.

Figure 6.6
Loss Rate Changes Under Plan 6



Population Changes



6.2 Another Perspective

The above simulations were done with the predicted changes in voluntary loss rates applied to only those pilots in 1987 who were listed in the Bowman data as being eligible to leave the service. If we assume that the effects of the pension changes introduced under Plan 6 apply to the entire pilot population, the increased losses of younger pilots because of the new pension are much larger. More importantly, there are significant differences in the changes predicted with the option value model and the ACOL model.

Figure 6.7a compares the changes in the pilot population because of the 1986 pension predicted by the two models. What is most noticeable is the large loss of pilots from 7 to 13 years of service predicted by the option value model when the ACOL model shows only a minuscule change. The losses in these cohorts amount to 490 with the option value model, but only 80 with the ACOL model. The difference in predictions until 16 years of service (where the two models intersect) is alarming from the point of view of a policy analyst who uses the ACOL model to recommend the pension change: 714 pilots are lost with the option value model; only 229 with the ACOL model.

It is interesting to compare this result with work done by Argüden in [3], where he investigated the effects of the 1986 pension plan on the Air Force enlisted population. Argüden used the Dynamic Retention Model of Gotz and McCall for his study, but not an estimated version. Instead, he produced a "calibrated" version, as described in [2], for which the parameters are merely plausible - selected so that historical retention rates of enlisted personnel are predicted very well.[4]

Figure 6.7b shows Argüden's comparison of the ACOL and Dynamic Retention Model predictions of the effects of Plan 6 on the enlisted population. As the option value model indicated with the pilot population, the DRM shows that the pension change will have far greater influence on personnel earlier in their careers than expected with ACOL predictions.[5]

I Chapter Two, I quoted Wise's remark that the option value model is a "poor man's" dynamic programming model, and that it is possible to look at it as an approximation to a (perhaps) more "accurate" view of decision making embodied in the dynamic programming framework. Though the population studied in this paper and the one considered by Argüden are different, the similar pattern of the effect of Plan 6 provides further evidence that the option value model is able to pick up complicated behavioral changes that a more complicated dynamic programming program model captures.

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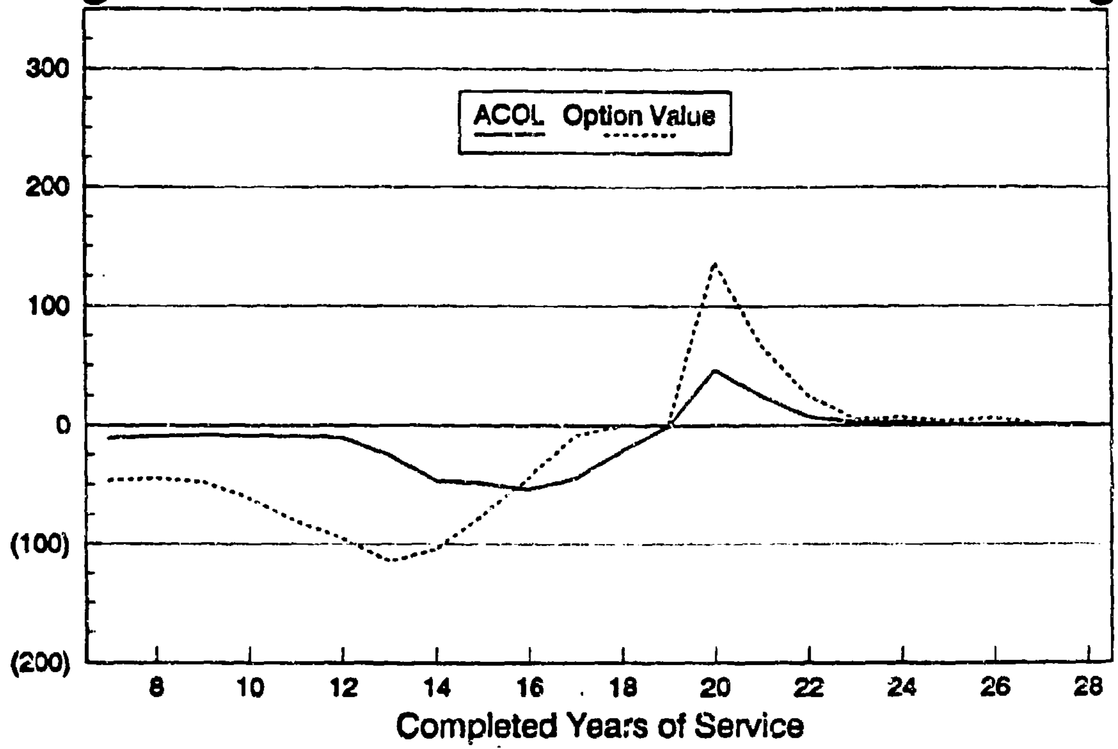
[4]The fact that he chose to do this instead of estimating the model is once again an indicator of the computational difficulty introduced by an individual "taste" variable in the model.

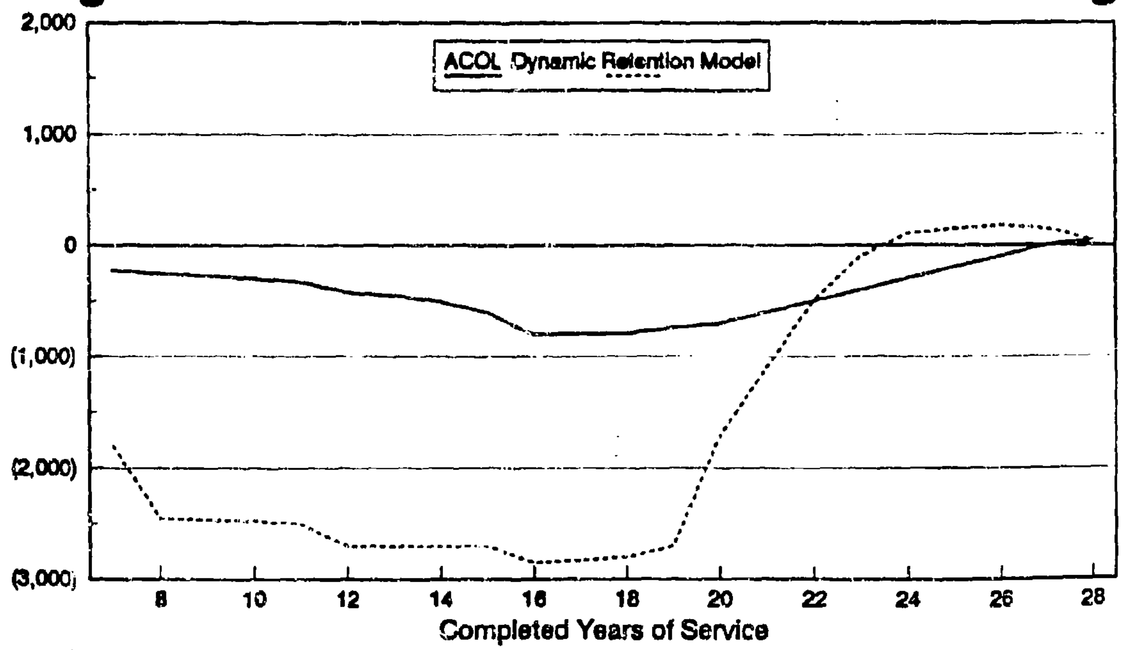
[5]The total enlisted population is about 20 times that of the total pilot population (approximately 450,000 versus about 22,000). If Figure 6.7b were scaled to take this into account, the similarity with Figure 6.7a would be even clearer.

Figure 6.7a Potential Effect of Pension Change



Using total 1987 pilot population

Figure 6.7b Potential Effect of Pension Change



Argudan's enlisted prediction

Conclusion

In this chapter, we have seen the usefulness of the option value model in predicting changes in departure behavior that result from modifications to the military pension system. In general, option value simulations show that changes that decrease the value of the pension when compared to the pre-1980 retirement system have a significant effect on the departure decision of pilots very early in their careers. The increased losses of pilots in the younger cohorts because of the 1986 pension change are especially important because they are so much larger than the losses predicted using the ACOL model.

Argüden notes that the 1986 pension change was intended to save $2.9 billion in the 1986 accrual funding of the military retirement budget, and concludes that because of his predictions of larger losses in enlisted personnel than expected with ACOL models, the anticipated savings could be offset by the need to make up for the losses - by recruiting and training more enlistees, by increasing current benefits to make up for the loss in retirement benefits, or by increasing benefits selectively to prevent people from leaving.

The option value predictions for pilots indicate that the same offset will occur for them, and this is especially troubling since the increased losses involve the very pilots targeted for special incentive pay because of anticipated shortages in fiscal year 1994.

CONCLUSION

This dissertation has been concerned with two problems. The first is the public policy problem of balancing the personnel needs of the military services with the costs of maintaining them. For populations such as Air Force pilots for whom specialized military skills may be transferable to lucrative civilian jobs, this means determining whether or not the government can afford to provide incentives to prevent the loss of those skills - or if any monetary incentives are a worthwhile means of preventing the loss. For the military population as a whole, it means carefully assessing the costs and benefits, both in terms of personnel changes and in terms of budgetary changes, of adjustments to more general forms of compensation such as the pension.

For both cases, the importance of being able to predict the effects of changes in compensation is clear, and this leads to the second problem: balancing the goal of predictive accuracy of a model of departure behavior with the burden of computational complexity. It is useful to find a model that is both "good" enough to help with making policy decisions and "easy" enough to provide that help in a reasonable amount of time.

The Modeling Problem

In Chapter Three, we saw that the option value model did much better in fitting the departure behavior of Air Force pilots than the simple version of the

ACOL model to which it was compared, and slightly better than a modified version of the dynamic programming model of Daula and Moffitt [15]. The added complexity of introducing a "taste" component in the dynamic programming model did not improve the fit appreciably, and doubled the computation time.

One of the original goals of this paper was to use the introduction of Aviator Continuation Pay in 1989 as an out of sample test to compare the predictive accuracy of the three models. This turned out not to be very useful because the effects of the bonus plan were minimal - there was not the uniform decrease in departure rates across the targeted cohorts that was hoped for. However, the option value model and dynamic programming models both performed much better than the ACOL model in an out-of-sample test on a different population of pilots.

We can therefore conclude that the option value model provides a better indicator of departure behavior than the ACOL model, and still captures complicated behavior that we would expect a rigorous dynamic programming model to capture.

An additional conclusion of the modeling tests in this paper is that the option value model is applicable in a different context than the one for which it was originally used. Stock and Wise [42a] were interested in the retirement behavior of individuals, many of whom were leaving the work force entirely but for whom no post-retirement information was available. Air Force pilots leaving the military - even the oldest ones - are almost certainly leaving for other employment, and the assumption that the salary of the new job grows in the same way as civilian pilot income allows a good fit of observed departure behavior.

The Policy Problem

The option value and dynamic programming models predict that fewer pilots will change their behavior because of the introduction of pilot bonuses than the ACOL model does. The importance of the difference is clear when long term effects of suggested bonus programs are compared with the effects predicted by the Congressional Budget Office using elasticities derived from ACOL models. Since much of the cost of proposed improvements in incentives comes from paying people who would have remained in the service without the increases in compensation, this means that the option value model predicts that the cost per pilot of improving retention with ACP is extremely high, and policy decisions based on this information might be different from those made using results from the ACOL model.

The fact that the military cannot compete with some civilian organizations in the amount of compensation available is not news, and monetary incentives for pilots were never thought to be the only method of improving retention. Nonetheless, Aviator Continuation Pay and the Glenn-McCain bill were expected to induce substantial decreases in pilot departures. The option value model shows that the pilot population is less sensitive to increases in military compensation than indicated by the ACOL model when the potential income stream from a civilian job is very large - even if there is an initial period of income loss as a civilian.

This could mean that, though pay changes can be easier to implement than other institutional changes, pilot retention would be more influenced by attention to other factors identified as "career irritants", such as separations from family, long hours, and duties unrelated to flying. Once again, the importance of these other factors is well recognized, but the potential gains from ACP indicated by ACOL analysis may have influenced the decision to address compensation issues before the others.

The 1986 change to the military pension was made to save $2.9 billion from the accrual account for retirement, and the potential personnel losses because of the decrease in an individual's pension value were deemed to be acceptable based on ACOL analysis. The option value model shows that the effects of the pension change on the pilot population may be greater than originally expected, and in particular that pilot losses for younger cohorts - the very pilots targeted by bonuses to improve retention - will be much larger than predicted by the ACOL model.

The consistency of the result that the pension change will affect personnel earlier in their careers with a similar result obtained using the dynamic retention model of Gotz and McCall lends more credence to the predictive capability of the option value model, and at the same time raises issues that Argüden discussed in his work. If the previously unexpected effect of the pension change actually occurs, the military will find itself in the uncomfortable position of developing ways to prevent the departure of younger pilots that could cancel the savings from the changes in the retirement system.

The work in this paper has dealt with the pilot population only, and the differences in ACOL and option value predictions are significant. If the differences in predictions for the whole officer population are similar to these, and departure rates for all younger officers increase as a result of the pension changes, the military will be faced with significant personnel challenges in the coming years.

This conclusion is tentative, because the simulations of the effects of pension changes assume that individuals in the military are suddenly faced with the prospect of a new pension plan of reduced value, and the question is whether to remain in the service with the new pension or to leave. Both of the pension changes in the past ten years have contained "grandfathering" provisions, so that persons already in the military would not be affected. People who have entered since August, 1986 know that they are covered by a pension plan that is less valuable than the one that existed before, and if retirement provisions enter into whatever calculations are made before enlistment or commissioning, the 1986 pension plan is the one that will be the basis for the decision to begin a military career. We will not know if later calculations done at the end of the initial service commitment will result in higher departure rates until people under the new retirement plan have their first opportunity to leave.

Summary

As mentioned in the introduction, understanding the retention effects of changes in compensation is only the first step in determining the overall consequences of pay and benefit adjustments. Recruitment, training, and assignment policy will also be affected, and the costs associated with these areas must be considered before the total costs of compensation changes can be calculated. The first step, though, is a very important one, and the option value model has proved to be a useful tool to ensure that it is in the right direction.

Epilogue

The problem of pilot retention and the disappointing effect of the introduction of Aviator Continuation Pay despite optimistic predictions of the increase in retention it would cause were the original motivation for using the option value model in studying the departure behavior of Air Force pilots. It is therefore a little ironic that as this work was being concluded, the March 18, 1991 issue of the Air Force Times contained an article that discussed the anticipated surplus of pilots in fiscal year 1994.

Cuts in the 1992 defense budget will cause the Air Force to lose a number of pilot positions, and because of this, General McPeak, the Chief of Staff of the Air Force, estimates that there will be about 2,500 too many pilots by 1994.[1] Among the remedies for the surplus are decreases in pilot production, the removal of more senior officers from flying positions, and initially putting new pilots in non-flying positions.

Pilots are not the only officer population that may be anticipating surpluses. Reducing the size of the United States contingent in Europe will mean fewer "command" positions for non-rated officers, and unless more officers leave the service voluntarily, the military may have to force some to leave because there are no jobs for them.

[1] I admit that this figure sounds suspicious, since it is so close to the pilot shortage figure that has been used since 1987.

This new situation points out the hazard of writing a dissertation on a problem that can be eliminated through a bureaucratic change, but it also may provide another opportunity for the option value model to prove useful. Civilian corporations have for years used early retirement options to encourage some employees to leave a firm, and it is not inconceivable that the military could consider adjustment to current severance pay levels in order to induce larger separation rates for over-populated segments of the services. The option value model, with its improved performance over the ACOL model, could help predict the effectiveness of suggested adjustments.

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APPENDIX 1

Derivation of Dynamic Programming Recursion Formula

In the text, we have that the probability of leaving the Air Force in year t is given by $\Phi(a_t)$ and the probability of remaining is $(1 - \Phi(a_t))$. The expected value of the best decision is

$E_{t-1}W_t$ = (Pr of staying) x (value of staying) + (Pr of leaving) x (value of leaving)

$$=(1-\Phi(a_t))E_t\left[W*_{1t}+\varepsilon_{1t}|\frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\sigma}>\frac{W*_{2t}-W*_{1t}}{\sqrt{2}\sigma}\right]$$

$$+\Phi(a_t)E_t\left[W*_{2t}+\varepsilon_{2t}|\frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\sigma}<\frac{W*_{2t}-W*_{1t}}{\sqrt{2}\sigma}\right] \quad (A1.1)$$

$$=(1-\Phi(a_t))W*_{1t}+\Phi(a_t)W*_{2t}+ \quad (A1.2)$$

$$(1-\Phi(a_t))E_t\left[\varepsilon_{1t}|\frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\sigma}<\frac{W*_{2t}-W*_{1t}}{\sqrt{2}\sigma}\right]+\Phi(a_t)E_t\left[\varepsilon_{1t}|\frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\sigma}>\frac{W*_{2t}-W*_{1t}}{\sqrt{2}\sigma}\right]$$

Now, as shown in Maddala ([34], p. 365), the mean of the truncated distribution is

$$E\left[\varepsilon_{1t}|\frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\sigma}>\frac{W*_{2t}-W*_{1t}}{\sqrt{2}\sigma}\right]=\frac{1}{2(1-\Phi(a_t))}\int_{W*_{2t}-W*_{1t}}^{\infty}x\frac{1}{\sqrt{2}\sigma}e^{-\frac{1}{2}\frac{x^2}{2\sigma^2}}dx \quad (A1.3)$$

$$=\frac{\sqrt{2}\sigma}{2(1-\Phi(a_t))}\phi(a_t) \quad (A1.4)$$

where ϕ is the standard normal density function. Similarly,

$$E\left[\varepsilon_{2t} \mid \frac{\varepsilon_{1t}-\varepsilon_{2t}}{\sqrt{2}\,\sigma} < \frac{W*_{2t}-W*_{1t}}{\sqrt{2}\,\sigma}\right] = \frac{\sqrt{2}\,\sigma}{2\Phi(a_t)}\phi(a_t) \tag{A1.5}$$

Substituting equations A1.4 and A1.5 into equation A1.2 and dividing both sides by σ gives us

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

as claimed.

APPENDIX 2

Income Predictions for the Pilot Sample

1. Regression coefficients

Dependent Variable: $\Delta \ln Y_t$

Regressor	Coefficient	Standard Error	t Statistic
$\ln(S_t)$	-.241	.006	-37.7
$(\ln(S_t))^2$	.050	.001	40.5
$\Delta\ln(Y_{t-1})$	1.209	.015	83.0
$\Delta\ln(Y_{t-2})$	-.153	.012	-12.4
$\ln(S_t)\ln(\Delta Yt\text{-}1)$	-.568	.006	-92.7
$\ln(S_t)\ln(\Delta Y_{t-2})$	.099	.006	17.3
D77	.286	.008	34.5
D78	.304	.008	36.6
D79	.270	.008	32.4
D80	.272	.008	32.7
D81	.333	.008	40.1
D82	.412	.008	48.8
D83	.359	.009	41.7
D84	.325	.009	38.0
D85	.331	.008	39.0
D86	.336	.008	39.8
D87	.312	.008	37.0
D88	.296	.008	35.1
D89	.314	.008	37.3
D90	.298	.008	35.4

SEE: .03794

Coefficients were estimated using 56,351 observations, including multiple observations for individuals. The income predictions were done using an average of the dummy variables for years 1977 through 1990 (D77 - D90).

The table shows coefficients for the regression using Basic Pay. A similar equation was estimated using Total Pay.

2. Calculation of Expected Utility

For the option value calculations, we need an estimate for the expected utility for an individual. To do this, start with a truncated Taylor series expansion of Y^γ about E(Y):

$$Y^\gamma \approx (EY)^\gamma + \gamma(EY)^{\gamma-1}(Y-(EY)) + \frac{1}{2}\gamma(\gamma-1)(EY)^{\gamma-2}(Y-(EY))^2 \qquad \text{(A2.1)}$$

$$= \left[(1-\gamma) + \gamma Y(EY)^{-1} + \frac{1}{2}\gamma(\gamma-1)(EY)^{-2}(Y-EY)^2\right](EY)^\gamma . \qquad \text{(A2.2)}$$

Thus, taking expectations of both sides,

$$E(Y^\gamma) \approx \left[\ -\gamma + \gamma EY(EY)^{-1} + \frac{1}{2}\gamma(\gamma-1)\frac{E(Y-EY)^2}{EY^2}\right](EY)^\gamma$$

$$= \left[1 + \frac{1}{2}\gamma(\gamma-1)E\left[\frac{Y-EY}{EY}\right]^2\right](EY)^\gamma . \qquad \text{(A2.3)}$$

Since the regression equation for earnings has $\ln Y_t$ as the dependent variable, $\ln Y_t$ is distributed normally with mean μ and variance σ^2. Thus, as shown in [39], page 300,

$$Y_t \sim N\left[e^{\mu+\frac{\sigma^2}{2}}, e^{2\mu+\sigma^2}(e^{\sigma^2}-1)\right] .$$

This means that

$$E\left[\frac{Y-EY}{EY}\right]^2 = \frac{\sigma_Y^{\,2}}{\mu_Y^{\,2}} = \frac{e^{2\mu+\sigma^2}(e^{\sigma^2}-1)}{e^{2\mu+\sigma^2}} = e^{\sigma^2}-1 . \qquad \text{(A2.4)}$$

Again using a Taylor series expansion,

$$e^{\sigma^2} - 1 \approx \sigma^2 . \qquad \text{(A2.5)}$$

Using the standard error of the estimate (SEE) from the regression for military income as an approximation for σ, and by A2.5 using it for the expression in equation A2.4, we can write equation A2.3 as

$$E(Y^\gamma) \approx \left[1 + \frac{1}{2}\gamma(\gamma - 1)SEE^2\right](EY)^\gamma . \qquad \text{(A2.6)}$$

To be consistent with equation 2.22 in the text, we assume that

$$E_t\left[\frac{(Y_s - E_t Y_s)}{E_t Y_s}\right]^2 = (s-t)\sigma^2 , \qquad \text{(A2.7)}$$

and the computer program implementing the option value model uses the expression

$$E_t(Y_s) \approx \left[1 + \frac{1}{2}\gamma(\gamma - 1)(s-t)SEE^2\right](E_t Y_s)^\gamma . \qquad \text{(A2.8)}$$