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# Personnel Management in the Military

## Effects of Retirement Policies on the Retention of Personnel

R. Yılmaz Argüden

January 1986

Rand

40 Years 1946-1986 PROJECT AIR FORCE

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# PREFACE

The pressure to change the military retirement system is mounting in the Congress and the Administration. An evaluation of the cost and military readiness effects of alternative retirement systems, however, cannot be made without an accurate assessment of the retention effects of different proposals. This report provides an evaluation of the adequacy of the existing retention models for retirement policy analysis, quantifies their limitations, suggests possible improvements, and develops a simulation methodology to test the improvements. It also examines the importance of paying analytical attention to the inputs of the retention models.

The results should be of interest to members of the manpower and personnel communities in all the military services and the Department of Defense who are evaluating the effects of alternative retirement policies. The simulation methodology was developed to evaluate the practical importance of the theoretical limitations of the retention models. It should be useful to policy analysts, economists, and statisticians who are faced with policy situations where the structure of the simple models is likely to change with the policy interventions that need to be analyzed (the rational expectations theory) and where more complex models are difficult to implement empirically.

The text of this report is the author's doctoral dissertation in The Rand Graduate Institute. The research was conducted under the Enlisted Force Management Project (EFMP), a joint Rand/Air Force project to develop a new, integrated, computer-based decision support system for the management of enlisted personnel. Rand's work on the EFMP falls within the Resource Management Program of Project AIR FORCE. The EFMP is part of a larger body of work in that program that is concerned with effective utilization of human resources in the Air Force.

## SUMMARY

Many studies of the military retirement system are based on models whose structures are likely to be changed by the policy interventions that they analyze. **Such models could lead to seriously biased predictions of the retention effects of alternative retirement systems.** This research examines the adequacy of the existing retention models for retirement policy analysis, quantifies their limitations, suggests improvements, and develops a simulation methodology to test the suggested and future improvements. It also examines the importance of paying analytical attention to the inputs of the retention models.

Reliable predictions of retention rates are essential in evaluating both the costs and military readiness effects of alternative retirement policies. Cost determination is fairly easy, but evaluation of the military readiness effects is much more difficult. The retention models could provide inputs to cost-benefit analyses by predicting the retention effects of alternative retirement systems. They could also be used to search for compensation packages that produce the same force profiles. (This approach permits side-stepping the more difficult issue of assessing military readiness effects.)

Behavioral models of retention incorporate four factors with varying degrees of success:

- military income opportunities,
- civilian income opportunities,
- persistent differences among individuals that influence their valuation of nonpecuniary benefits of military and civilian life (tastes), and
- random events--such as sickness in the family--that may influence individuals' retention decisions (random shocks).

All the models examined assume that retention decisions are influenced not only by current military and civilian compensation levels but also by life cycle income opportunities offered in these two

sectors. The models calculate a cost-of-leaving (COL) measure, which is the difference between the value of staying in the military for at least one more term and the value of leaving the military at the current decision point. COL is related to the observed retention rates to estimate the sensitivity of military personnel to compensation levels. Because the military personnel system is essentially a laterally closed system, those who leave usually do not come back. Therefore, the value of leaving is straightforward to calculate. But those who stay at a particular decision point will have to make other stay or leave decisions at future decision points (each time their contracts are up for renewal and the value of staying depends on how long an individual stays with the military). **One of the major differences among retention models originates from the way they decide which future decision point to focus on, or how they weight the values of staying until different future decision points.**

Of the four factors that are incorporated in these models, military and civilian income opportunities are directly observable (despite the difficulties of doing so), but tastes and random shocks are not. **The most important differences among the retention models are caused by the approaches they take in modeling tastes and random shocks.**

There have been no major changes in the deferred compensation component of the military compensation package in the last 40 years, making estimation of the potential effects of changes in the retirement policies difficult. Therefore, theoretical rigor and internal consistency of the retention models, which are less important in other applications, become very important in retirement policy analysis. This analysis showed that the Dynamic Retention Model (DRM), which was developed by Gotz and McCall (1984), is the most theoretically sound model. However, the empirical implementation of a theoretically sound but complex model may be very difficult. Furthermore, this difficulty increases with the need to disaggregate the retention effects of alternative policies by various personnel characteristics.

The ability of the retention models to provide information on retention rates disaggregated by year-of-service (YOS), grade, occupational group, and quality levels is important for three reasons. First, such disaggregation of retention effects enables better assessment of the cost and military readiness effects. Second, disaggregation may provide more accurate assessment of the retention effects of alternative policies. Third, disaggregation provides a means of evaluating the equity aspects of various policies.

Aside from the DRM, three other simpler retention models were reviewed:

- the present value of cost of leaving (PVCOL) model,
- the perceived pay model (PPM), and
- the annualized cost of leaving (ACOL) model.

A theoretical review suggested that these models could have serious limitations in analyzing retirement policies. The best way to evaluate the adequacy of a model for policy analysis is to compare the model's predictions with what actually happens when a policy is changed. To be able to apply this test to retirement policy models would require waiting for the implementation of a new retirement policy, but then the model would no longer be necessary for making predictions about this particular policy.

Therefore, the evaluation of the adequacy of the simpler models for retirement policy analysis was based on a simulation methodology. This methodology used a theoretically sound model, the DRM, to generate pseudo-data under different policy settings.[1] Then the simpler models' predictions were evaluated against simulated retention behavior. Just as military capability cannot be fully tested without going to war, the retention models cannot be fully tested without actually changing the retirement system. But just as using war games can provide insight into military capability, simulation can be used to evaluate the adequacy of the simpler models for retirement policy analysis. The simulation methodology was used

- to identify and test the adequacy of improvements to the simpler models,

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[1]The simulations under the current retirement policy mimic the actual retention rates.

- to quantify and correct for the biases caused by the input assumptions.
- to quantify and correct for the biases in these models when analyzing specific retirement policies, and
- to identify the policies that cannot be analyzed by the simpler models,

**The analysis focused on the most commonly used retention model, the ACOL model. Many of its applications, such as QRMC V ACOL, suffer considerable biases because of inadequate modeling of the censoring of tastes, random shocks, and being a maximum regret model.** The first two limitations are more important than the last in most applications. The first two biases work in opposite directions and the net effect is to underpredict the effects of retirement policy changes on retention rates, particularly in the earlier YOS where more individuals are affected. With the types of policies analyzed in this report, the ACOL model captures *only* about a quarter to a third of the changes in the retention rates at YOS 8 and 12.

Adding a taste proxy (which is a function of the proportion of an entering cohort still in the military to make stay or leave decisions at a particular decision point) greatly improves the predictive ability of the ACOL model. Estimation of a variance components model along with the inclusion of a taste proxy is likely to reduce the biases even further. Also, any additional variable that explains some of the variance of the random shocks, such as the unemployment rate, is likely to reduce the biases.

The maximum regret nature of the ACOL model is the most difficult aspect to deal with. Fortunately, most retirement policies do not affect the second best time horizon differentially from the best time horizon. Therefore, this limitation does not prevent ACOL's use in analyzing the effects of most retirement policies.

The analysis of the practical importance of the input assumptions indicated that the assumptions made in calculating COL measures could greatly affect ACOL predictions. Biases in the input assumptions would be translated into biases in the predictions. In particular, the discount rate assumptions seem to have the largest influence on the predicted retention rate effects, because the smaller the discount rate, the larger the weight given to the retirement benefits in the total compensation package. Then, in order of importance, the assumptions about civilian income opportunities and promotion probabilities could influence the predictive capability of the ACOL model.

The most important dimension of a force profile is YOS, because it influences the retention rates, costs, and readiness effects most heavily. Disaggregation increases the accuracy of retention rate predictions for two reasons. First, when separate groups of personnel with different retention behavior can be identified, the observed retention rates of personnel who have been through a particular decision point provide information about the attractiveness of military life (with its compensation level and other nonpecuniary benefits) to similar personnel who have yet to face that decision point. If military life is very attractive or very unattractive, small changes in the compensation levels are unlikely to have major effects on retention rates. Second, **past retention rates of a certain group of personnel provide information about those who have chosen to stay until now**. In particular, if very few personnel stayed from a given cohort, then those who stayed would have done so despite unattractive (as seen by individuals in the same starting cohort) military compensation levels. Therefore, those who stayed are unlikely to change their decisions with small changes in compensation levels. Even a 10 percent persistent difference in civilian income or promotion opportunities could lead to major differences in the retention rates of different groups of personnel.

The general lessons that can be drawn from this research are:

- explicitly laying out the assumptions of the theoretical model and the estimation procedure is essential in understanding and using econometric models and in ensuring internal consistency;
- not doing so can lead to considerable prediction errors;
- a theoretically superior model is not necessarily the best one to use for policy analysis because estimation of its parameters could be very difficult, and simpler models may be able to approximate the complex models (and the real world) closely enough for analysis of many policies;

- a theoretically rigorous and consistent view of the world is essential in understanding the limitations and applicability of different approximations (i.e. models) to reality.

The theoretical concerns are similar to the ones in rational expectations theory in macroeconomics, but the simulation methodology provides an approach to evaluate the practical importance of these concerns in a given policy environment.

In sum, **the retention models of many previous studies of the military retirement system have serious biases that influence the policy recommendations**. Such models should be improved before they are used for retirement policy analysis. Some improvements are suggested and a simulation methodology is provided to test these and other future improvements. Short of changing the policies to evaluate models, the simulation approach may be the best way to evaluate the practical importance of the theoretical limitations of the simpler models under policy settings that may change their structures. Finally, a word of caution to the users of these models: The computer programs that implement these models should not be viewed as black boxes that somehow provide accurate estimates of the retention effects of various retirement policies; they should be *evaluated* in light of the findings of this research before policy recommendations are made.

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# I. INTRODUCTION

Federal outlays for the military retirement system in the United States nearly quadrupled in constant dollars during the past two decades, to its current level of $16.5 billion in FY84.[1] Although the costs are projected to grow more slowly in the future, in an era of increasing federal budget deficits, the military retirement system is becoming an issue of increasing public concern. Pressure to reevaluate the system is mounting in the Congress and the administration. In a congressional hearing Budget Director David Stockman called the system a "scandal" and an "outrage." Representative Les Aspin has called it "a boondoggle." The *Wall Street Journal* has said it is a "gravy train." But costs alone are not an adequate criterion for judging the appropriateness of the military retirement system. The incentives offered by the retirement system in conjunction with active-duty pay help to meet the military's manpower needs in an all-volunteer force environment. The primary goal of this study is to improve our capability to assess the effects of alternative retirement policies on force profiles. Although our empirical work is based on Air Force enlisted personnel, the methodology can be generalized to enlistees and officers in all services.

## THE MILITARY RETIREMENT SYSTEM

The current retirement system provides an immediate, lifetime annuity to personnel who retire after 20 or more years of service. The annuity is equal to 2.5 percentage points of final basic pay[2] multiplied by the number of years of service, and is inflation protected.[3] Basic

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[1]In constant 1984 dollars.

[2]All retirees whose date of entrance into military service is after September 7, 1980, will have retirement pay based on the average pay in the three highest years, rather than on final basic pay (P.L. 96-342, 94 Stat. 1100, September 8, 1980).

[3]The Congress placed a three-year limitation on CPI adjustments for FY83-FY85 for retirees under age 62 (P.L. 97-253, 96 Stat. 790, September 8, 1982).

pay is about 70 percent of military compensation, so an individual who retires after 20 years of service receives about 35 percent of his final total military compensation as retirement pay. A chief master sergeant who serves the maximum 30 years in the military gets 75 percent of his basic pay, about 55 percent of his final pay, as retirement pay. An average retiree is a master sergeant with 23 years of service. Under the 1985 military pay schedule, his annual retirement pay would be $11,800. Typically, he receives retirement pay for an average of 35 years starting in his early forties.

Currently, there are about 1.4 million beneficiaries of the military retirement system.[4] Between 1963 and 1984, outlays for military retirement increased from $4.2 billion (in 1984 dollars) to $16.5 billion (CBO, 1984). Although less than 30 percent of all active service members are in the Air Force, payments to Air Force retirees constitute 40 percent of total retirement costs because a higher proportion of an entering cohort reach retirement eligibility in the Air Force than in other services. Three factors have quadrupled the outlays for the military retirement system in the past two decades: Wage growth averaged 1 percent real growth per year; the retiree population increased as a result of the force levels during World War II and the Korean War;[5] and a statute in effect between 1969 and 1976 (CBO, 1984 and QRMC, 1984) caused faster increases in retirement pay than the CPI. According to CBO estimates, the growth in retirement costs will continue, but at a much slower rate (1.1 percent a year) than the growth in the past two decades (7.0 percent per year). By the end of the century, retirement costs are projected to increase to $19.4 billion (in constant 1984 dollars). Future growth in outlays will occur primarily because of increased life expectancy.

Outlays are benefits paid to current retirees, rather than payments into an account that will eventually be paid to those who are currently on active duty. Therefore, they reflect the effects of past policies

[4]About 7 million households are indirectly affected by the military retirement system (1.4 million retirees and 2.1 million active service members and their families).

[5]There is no projected increase in the retirement population from the Vietnam War.

rather than current ones. They do *not* reflect the value of the retirement system for personnel now in service. This dilemma has faced those who are trying to reduce the current budget deficits. Reducing the benefits for those who are already on the retirement rolls is not politically acceptable.[6] But decreasing retirement benefits for personnel currently on active duty will not affect the budget for many years.

In 1984, the Congress acted to require DoD to fund service retirement costs using the advance funding concept and an accrual accounting technique beginning with FY85.[7] Under this approach, DoD will have to finance a pension fund large enough to cover expected future retirement benefits earned by current service personnel. Accrual charges are usually expressed as a percentage of basic pay, and currently the accrual rate for the retirement fund is about 50 percent of basic pay. Therefore, starting in FY85, the current defense budget in principle reflects the effect of current manpower and compensation policy decisions on the cost of future benefits earned by current service members. Any changes in the retirement system will now be reflected in the current DoD budget so that the decisionmakers will consider the complete retirement cost consequences of their decisions.[8] In addition, even if all the current members are grandfathered, the changes to the retirement system will still be reflected in the current budget. However, actual federal outlays will continue to reflect the cost of benefits paid to personnel who are already retired.

## History of the Military Retirement System

The military retirement system has a long and complex history[9] but it has not changed much since the late 1940s. The earliest provisions

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[6]Similar arguments hold for those who have already served close to 20 years but have not yet reached retirement eligibility.

[7]P.L. 98-94, DoD FY84 Authorization Act.

[8]Gotz (1985) proposes some changes to DoD's accrual accounting and funding system to make sure that the budgets of different DoD decisionmakers will reflect the complete retirement cost consequences of their actions.

[9]For further details see QRMC V (January 1984).

for the maintenance of disabled service members dates back to the Pilgrims at Plymouth in 1636. Annuities based solely on service (nondisability) had first been promised in 1780, but after the war the claims were settled for less than the full value. The controversy on the issue was finally resolved in 1818, when Congress provided relief to surviving Revolutionary War veterans. With the outbreak of the Civil War came the first voluntary retirement Act to retire older officers no longer fit for field duty.[10] Later, Acts in 1861[11] and 1862[12] authorized involuntary retirement for age or years of service. Enlisted members were first provided with retirement benefits in 1885.[13] The Act of 1916[14] established the method of calculating retirement pay as a multiple of active-duty pay and 2.5 percentage points for each year of service up to 30, or a maximum of 75 percent of such pay. Between 1916 and until after World War II, the changes in the system were primarily on the length of service requirements for eligibility. After World War II, the eligibility requirement for officers and enlisted members in all services was uniformly established to be 20 years of service. Since then, the basic structure of the military retirement system remains the same; the only change of note was in 1980, when an Act declared that members who entered active duty after September 7, 1980 will have their retirement benefits calculated on the basis of the average of their highest three years' pay, rather than final basic pay.[15]

Adjustment of retirement benefits to reflect changes in active duty pay and inflation has a long history as well. However, this aspect of the system had more recent changes. The principle of "recomputation" was established in 1870.[16] The Acts provided that benefits for those who were already retired be adjusted to reflect the changes in active-duty pay. Until 1958 recomputation was the basis of adjustments to

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[10] 3 August 1861 (12 Stat. 287).

[11] (12 Stat. 329).

[12] (12 Stat. 594).

[13] February 14, 1885 (23 Stat. 305).

[14] August 29, 1916 (P.L. No. 64-241, 39 Stat. 579).

[15] September 8, 1980 (P.L. No. 96-342, 94 Stat. 1100).

[16] July 15, 1870 (16 Stat. 315 and 16 Stat. 321).

retirement benefits. In 1963, in an effort to reduce costs, post-retirement adjustments of retirement pay were indexed to the Consumer Price Index (CPI). Ironically, the increase in CPI has exceeded the capped active-duty pay adjustments in some years. In 1982, the adjustments were temporarily delayed and limited to a portion of the increase in CPI for retirees under age 62.[17]

### Comparing Force Profiles

The "ideal" force profile has the required number of military personnel at each experience level (years of service) and an appropriate skill mix to accomplish the mission of the military. However, this ideal force profile is not attained because the military personnel system is essentially a closed system. That is, lateral entry of non-prior service personnel is rarely utilized. Therefore, managerial positions are held by those who have been in the military for a long time to gain the required experience. Because high level positions can be filled only from within the military, stability of the size of the career force (military personnel with more than 8 YOS) to provide an adequate supply of individuals who could fill high level positions is one of the important considerations in military personnel management.

Another consideration is the ability to separate (voluntarily or involuntarily) those who have been in the military for a long period. Because of the strong link between the years served and the level of position attained, up-or-out policies have been instituted to ensure rapid promotion opportunities to younger personnel.

Manpower requirements are likely to vary under changing circumstances. For example, the increased complexity of military technology and reduction in the pool of youth available for the services may change the ideal force profile. The military should be able to compete with civilian employers to attract and retain adequate numbers of capable people. Personnel policies should be flexible enough to adapt to changing conditions.

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[17]The Congress placed a three-year limitation on CPI adjustments for FY83-FY85 (P.L. 97-253, 96 Stat. 790, September 8, 1982).

## Incentives of the Current Retirement System

The size of the retirement annuity heavily influences personnel decisions to stay with the military. Because military personnel receive almost no benefits if they leave before serving 20 years, retention rates steadily increase until that point. Most personnel then retire within the first three years of retirement eligibility.

Table 1 shows the proportions of YOS groups that will stay until 20 years of service. Table 2 indicates that 45 percent of the enlisted members[18] who reach retirement eligibility leave the military in the first year after eligibility and 80 percent within the first three years. Previous research has also shown that the effect of current economic variables, like military/civilian pay ratios and unemployment rates, on retention rates declines as the 20-year point comes closer (Argüden and Carter, 1984).

Table 1

PERCENTAGE WHO WILL REACH RETIREMENT ELIGIBILITY BY YEARS OF SERVICE COMPLETED[a]

| YOS | Enlisted | Officer |
|---|---|---|
| Entrants | 11.5 | 17.0 |
| 4 | 30.5 | 32.0 |
| 8 | 59.4 | 50.1 |
| 12 | 82.4 | 69.3 |
| 16 | 92.9 | 84.1 |

[a]Percentages are based on base case retention rates of QRMC V, "Annualized Cost of Leaving Model," *Fifth Quadrennial Review of Military Compensation*, Vol. I-B, App. I, January 1984.

[18]The enlisted component constitutes about 80 percent of the active force.

Table 2

PERCENTAGE OF RETIREMENT ELIGIBLES LEAVING BY YEARS AFTER RETIREMENT ELIGIBILITY[a]

| Year | Enlisted | Officer |
|---|---|---|
| First | 45 | 29 |
| First 3 | 80 | 51 |
| First 6 | 91 | 77 |

[a]Percentages based on base case retention rates of QRMC V, "Annualized Cost of Leaving Model," *Fifth Quadrennial Review of Military Compensation*, Vol. I-B, App. I, January 1984.

By not providing any benefits until members serve for 20 years, the military retirement system helps ensure a stable supply of mid-length careerists between 10 to 20 YOS. Not only are the retention rates high between 10 and 20 YOS, but they are also less sensitive to exogenous economic conditions than they would be in absence of the military retirement system (Argüden and Carter, 1984).[19] Similarly, the 20-year vesting point means that retirement benefits have very little effect on the retention rates at the first decision point, typically 4 YOS.[20] By providing an immediate lifetime annuity upon completion of 20 YOS, the current military retirement system encourages many members to leave voluntarily in their early forties and makes it easier for the services to separate others involuntarily.[21]

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[19]Also, sensitivity to exogenous economic conditions increases right after the retirement eligibility (Skoller, 1985).

[20]Benefits that are 16 years into the future are heavily discounted by young first-term personnel. A similar argument can be applied to those who are at the second decision point, typically at YOS 8 for enlisted personnel. However, the "pull" effect of retirement will be higher at the second decision point. The term of enlistment concept is more applicable to the enlisted component, about 80 percent of the total force.

[21]Primarily through high-year-of-tenure (HYT) policies.

Although they provide desirable incentives in meeting personnel objectives, these same features contribute to some of the military's manpower problems. First, because military personnel receive almost no benefits if they separate before 20 YOS, the services are reluctant to separate unproductive personnel involuntarily as they come closer to the 20th YOS. They do have ample opportunity to identify and separate such personnel much earlier in their careers. Hence, the "lock-in" effect on career personnel is more important than having to keep some low productivity personnel for longer periods than desirable. Second, the current system provides little incentive to stay for those who are in their early careers. In the early 1990s the eligible pool of youth for military service will decline, and the current system is unlikely to help much in increasing the retention rates in the early years of service. In the current system, each additional year after 20 YOS increases the annuity for the military personnel by 2.5 percentage points,[22] but those who choose to stay forfeit receiving retirement annuities until they retire. Furthermore, there is evidence that the transition to civilian life becomes more difficult the longer the individual stays with the military.[23] Hence, the current system makes it harder for the services to keep personnel after 20 YOS.[24] Those affected by this are the most highly skilled and senior personnel and may be increasingly important for the services as military technology becomes more complex.

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[22]Promotions also increase base pay for the calculation of retirement annuities.

[23]Cooper, Gunther-Mohr, and Lewis (1984) suggest that the magnitude of this effect is large. Although the argument that the experience in military service is not fully transferable to civilian employment is appealing, it is unlikely to be the only reason for the observed earnings loss of personnel who stay in the military for more than 20 years. In particular, those who receive attractive civilian offers are less likely to remain in the military past 20 YOS. If civilian offers are correlated with capability, then the "observed" earnings loss figures will be biased upward for personnel who retire after the 20th YOS.

[24]The average age of military personnel is increasing, and very large cohorts are currently moving into the career years (8+ YOS). This is probably not a problem, except in selected occupations.

## SUPPORT FOR POLICY ANALYSIS

This study provides means of estimating the effects of different retirement systems on force structures. The models that were used in previous studies will be evaluated and, whenever possible, improvements will be provided.

Since 1960, the military retirement system has been the subject of ten major studies,[25] all of which have recommended significant changes to the current system. The *First Quadrennial Review of Military Compensation* (QRMC I) proposed contributions by individuals to a retirement fund. Most of the studies proposed early vesting, generally at about 10 YOS, and deferred annuities, to about age 60. Severance pay for involuntary separations, grandfathering current members, and full CPI protection were common recommendations by most but not all of the studies. The last of these studies, QRMC V, concluded:

> It is important to note, however, that none of the previous studies have satisfactorily analyzed the impact of their proposed modifications on the Service manpower requirements. (QRMC V, Executive Summary, 1984.)

Analysis of the effects of alternative retirement systems on force structures is essential in evaluating these effects. Most proposed systems have emphasized cost savings. Any change to the retirement system has a direct effect on costs through changes in the amount paid to each retiree, but it also changes the incentives of the voluntary force to stay with the military. One important effect is that a different number of service members are available for retirement, affecting the total system cost. More important, changes in military manpower influence military readiness.

Evaluation of cost changes for any proposal requires the distribution of the force by years of service and grade because military pay (active and retirement) is primarily tied to these factors. There

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[25]See Appendix D for a summary of the recommendations of these studies.

is no commonly accepted method to trade off readiness gains in one part of the force profile against losses in another part. Capabilities in different areas are heavily influenced by the quality of available personnel.[26] Available equipment and the nature of the threat also affect readiness. The personnel management system of the military has more than 1500 different skills, ratings, and specialties to deal with the complex nature of military manpower requirements. The evaluation of the effects of different force profiles on readiness could best be done by the management of the military. However, evaluation would be enhanced if there were detailed breakdown of force profiles by different occupational groups and quality levels.

This study intends to improve the estimating capability for the potential effects of different retirement systems on force structures. Flexibility of methodology is emphasized. The same methodology can be used for long-term policy analysis of changes in other parts of the military compensation system. For example, a change in the retirement system can be used to identify problem areas and possible management responses to obtain adequate force profiles. Finally, if the retirement system changes, some of the models that are (and will be) in use for day-to-day management of the force in the Enlisted Force Management System (EFMS)[27] will have to be reestimated. This methodology could be substituted for those models until adequate data become available for their reestimation.[28]

## STUDY APPROACH AND ORGANIZATION

The most appropriate information that can be used to predict the retention effects of potential changes to the military retirement system

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[26]For an excellent attempt to operationalize the concept of "quality" by looking at such observable characteristics as education level, AFQT scores, and promotion speed, see Ward and Tan (1984).

[27]EFMS is a decision support system being developed by The Rand Corporation and the Air Force. For further details see Carter et al. (1983).

[28]To improve accuracy, some of the models developed for the EFMS are conditioned on the current structure of the compensation system; a major change in the retirement system could invalidate the current estimates. For example, see Argüden and Carter (1984).

would be the behavior of U.S. military personnel under different retirement systems. Unfortunately for the analyst, the military retirement system has not changed much in the last few decades. Three other approaches can be utilized: Military personnel can be surveyed to determine their potential responses to changes; retention effects of changes in civilian or other nations' military retirement systems can be used; or responses of U.S. military personnel to other compensation changes could be used as the basis of predictions.

Survey data have two important limitations. First, the knowledge that the responses will be utilized in modifying the retirement system may bias some respondents' answers. That is, they may indicate a preference for a particular change by saying that they would stay, even though they might not do so if actually faced with that decision. Second, they may not realize the full effect of subtle changes when they are responding to a survey, whereas after a change takes takes place more information will be available to them through their peers. Although survey data may reflect more drastic changes than exhibited by historical data, well-publicized attempts to modify the retirement system could considerably bias responses to a survey. Therefore, this approach is not used here.

Using information from other retirement systems is very difficult because many factors are unique to the U.S. military. Furthermore, other retirement systems are not similar to the current U.S. military system and were not changed in ways that are being considered for the U.S. military system. Comparison of changes in civilian retirement systems cannot adequately show the effects of alternative military retirement systems. The Government Accounting Office (GAO, 1983) and National Defense University (QRMC V, Vol. I-A, App. C., 1984) have compared the U.S. military retirement system with other nations' retirement systems. Their conclusions confirm that there are important structural differences between the retirement systems of the United States and other nations. Other nations' retirement systems were primarily designed to augment old age pensions, not to be recruitment and retention incentives, deferred compensation, or current pay for mobilization recall. Therefore, this approach is not used either.

The retention behavior of current service members under changing economic conditions and military compensation levels is the best barometer of how they will behave under different retirement systems. Lack of variance in the deferred compensation component of the full package makes it difficult to predict changes in behavior. Nevertheless, behavioral models should permit analysis of the potential effects of different retirement systems on personnel retention, hence on force profiles.

The last comprehensive review of the military retirement system was conducted by QRMC V; they took a behavioral approach to produce their retention rate predictions. Section II reviews the behavioral models that have been used in evaluating retention effects of retirement systems. Theoretical limitations of existing models are identified. Particular emphasis is given to the annualized cost of leaving (ACOL) methodology used by QRMC V.

Section III describes a simulation methodology that was used to quantify the theoretical limitations of the models described in Sec. II. The inputs to the simulation model and its calibration are also discussed.

Section IV describes the quantification of the theoretical limitations of the ACOL methodology and introduces some modifications to improve its performance. Section V analyzes the sensitivity of retention rate predictions under different retirement policies to assumptions about civilian income opportunities, promotion probabilities, and implicit discount rates. Section VI provides analyses of several retirement policies. The last section summarizes the conclusions and policy implications of the study.

# II. BEHAVIORAL MODELS OF RETENTION[1]

The models that have been used to analyze the effects of different retirement systems on force profiles are: (1) the present value of cost of leaving (PVCOL) model,[2] (2) the perceived pay model (PPM),[3] (3) the annualized cost of leaving (ACOL) model,[4] and (4) the dynamic retention model (DRM).[5] Particular emphasis is placed on the ACOL model and the DRM because ACOL is the most commonly used model and DRM is the theoretically most rigorous model. The DRM contains some of the other models, including ACOL, as special cases.

## FACTORS INCORPORATED IN RETENTION MODELS

The primary purpose of behavioral models of retention decisions of military personnel is to analyze the incentive effects of different compensation packages on individual behavior. That is, the military compensation package is the policy variable. Therefore, the first factor incorporated in these models is military income opportunities. Individuals are explicitly recognized as rational actors whose objective is to maximize their expected utility. The individuals' decisions are influenced not only by the military income opportunities but also by their alternatives. Therefore, the second factor incorporated in these models is civilian income opportunities. However, financial returns are not the only elements in individuals' utility functions. In particular, the nonmonetary benefits and disamenities of military employment and civilian employment are quite different. Furthermore, the value of the nonpecuniary factors is likely to differ among individuals. The

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[1]I would like to thank Glenn Gotz who has been instrumental in shaping my understanding of retention behavior.

[2]Gotz and McCall (1979); Warner (1979).

[3]Slackman (1981).

[4]Warner (1979).

[5]Gotz and McCall (1980, 1984).

difference in the value attached by individuals to the nonpecuniary elements of military and civilian employment is called "taste."[6] The third factor incorporated in these models with varying degrees of success is the persistent difference in tastes among individuals. The fourth and final factor is the effect of random shocks (such as especially good or bad assignments, a major sickness in the family, or a new commanding officer's arrival), which may influence individuals' decisions to stay in or leave the military.

In an all voluntary force environment, military personnel commit themselves to military service for limited time periods, usually four years for enlisted members. Therefore, they face multiple stay/leave decisions during their careers.

### Military Compensation

At each decision point, airmen face not only different current earnings opportunities but also different deferred earnings opportunities between military and civilian employment. The current military income opportunities are well known.[7] The future military income opportunities are uncertain in two ways: (1) The pay that will be associated with particular YOS/grade categories in the future is uncertain; and (2) whether and when an airman will be promoted to successive grades is uncertain. The first uncertainty is not incorporated in any of the models, and the promotion path of individuals is assumed to be the same for all members of the cohort in some models. When this assumption is made, the differential effects of alternative compensation policies by grades cannot be analyzed. At the same time, it is usually assumed that the common promotion path is the median grade at each YOS. Therefore, any policy change that does not affect those who are at the median grade but may affect those who are not at the median grade cannot be analyzed either. In some of the models, the airmen are assumed to move among YOS/grade cells according to known

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[6] In empirical implementation, any unmeasured persistent peculiarities among individuals will be included in this factor.

[7] Military pay is based on grade and YOS. Any special pay an individual may be getting is based on his occupation, which is also known.

promotion probabilities.[8] This assumption enables analysis of different promotion policies and of compensation policy changes by grade.

## Civilian Income Opportunities

The current civilian income opportunities may be known to the individual if he received an offer, but they are not known to an analyst who is trying to predict the individual's behavior. Otherwise, the individual has some uncertainty, but it is likely to be smaller than the analyst's uncertainty. Similarly, future civilian income opportunities are uncertain for both the individual and the analyst. None of the current models explicitly deal with such uncertainties, current or future.[9] Therefore, information available to the individuals today is assumed to be the same as will be available to them in the future. Individuals' decisions are assumed not to be affected by the possibility that their beliefs about the future may change over time.[10] Section III discusses civilian income opportunities in more detail. For the time being, assume here that either the uncertainties in evaluating military and civilian income opportunities do not exist, or the individuals know the expected values of military and civilian income opportunities and they are risk neutral.[11]

When faced with a decision to leave or stay with the military, each member of the cohort will compare his expected future income stream if he stays, with the future income stream he expects to get if he leaves now. The retention models develop some measure of the difference between the "value" of the income stream from staying in the military

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[8] "The assumption of perfect knowledge of the promotion probabilities is not very stringent. The promotion probabilities do not fluctuate markedly from year to year unless by policy, and the infrequent changes in policies are usually known in advance." (Gotz and McCall, 1980.)

[9] Except see Gotz and McCall (1979 and 1983).

[10] In this sense, the models are not dealing with an expectations formation process. Frequent and major changes to the compensation system may influence the expectations formation process, just as a change from a noninflationary environment to a high inflation environment may have an effect on expectations. Therefore, the uncertainty of the predictions of the models will be larger when major policy changes are considered.

[11] At least one of the models has been extended to allow for risk aversion. Gotz and McCall (1983).

and that from leaving the service now. This difference is called the cost of leaving, and it is related to the proportion of airmen who decide to stay (the retention rate) through some supply function to estimate the parameters of the models.

Calculation of the "value" of an income stream requires a metric to trade off between current and future income. This metric is the implicit discount rate. Although the models differ in how they calculate cost of leaving measures, they all utilize implicit discount rates in their calculations. Effects of different assumptions about implicit discount rates are discussed in the following sections. The different methods of calculating cost of leaving will be discussed in explaining the models.

The expected future income stream from staying depends on how long an individual plans to stay with the military. That is, an individual may decide to stay because of the attractiveness of four more years of service with the military, or of reaching retirement eligibility, or of a full 30 year career. Some models calculate a cost of leaving measure for each of the future decision points by calculating the difference between the value of staying until each future decision point and the value of leaving now. Then they use the maximum cost of leaving in estimating the parameters of the model. These are called "maximum regret" models because they compare the value of staying until the "best" future decision point with the value of leaving at the current decision point. In evaluating the effects of a compensation policy change, the "maximum regret" models predict no change in the retention behavior as long as the "best" future decision point and the value of staying until that point do not change. However, in an uncertain world, changes in the values of staying until the second or third best years are also likely to affect retention behavior. Also, the best year may be different for different subgroups in a cohort. If such groups cannot be differentiated, the "maximum regret" models are likely to miss the effects of compensation policy changes that influence the value of staying until decision points other than the best one. Other models use a weighted average of the values of leaving at each future decision point in calculating cost of leaving measures. They use the probability of staying until each of the future decision points as basis for weights. However, the probabilities of staying until different future decision points are not known under different policies, so these models require an iterative approach, which complicates them. *One of the major differences among retention models originates from the way they decide which future decision point to focus on, or how they weight the values of staying until different future decision points.*

## Tastes

If there were no effects of tastes or random shocks, then each member of the cohort who faces the same military and civilian income opportunities would make the same stay/leave decision. But individuals differ in their tastes toward military service.[12] Therefore, at the first decision point those with higher tastes toward military are more likely to stay. The voluntary retention decisions act to sort out those who have high tastes for the military from those who do not. As the cohort ages, the concentration of individuals with higher tastes for the military increases. Under similar economic conditions, because the individuals with greater taste for the military are more likely to stay in military service, the retention rates increase with years of service. This increase is distinct from any increase in the financial incentive to stay with years of service. That is, if the responses of a cohort to the same cost of leaving are compared at the first decision point and at a later decision point, the retention rate will be higher at the later decision point. Some of the retention models do not capture the effect of increasing average tastes for military service of a cohort on the increasing retention rates with years of service. Such models will attribute all of the increase in retention rates to financial incentives. Hence, they are likely to overpredict the effects of compensation changes.

Inadequate modeling of tastes leads to two other problems. First, tastes provide a link between past compensation policies and current retention rates. This cannot be captured without modeling tastes.

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[12]This may be because of personal differences in the valuation of the nonpecuniary elements of military and civilian life or it may capture other unmeasured persistent personal peculiarities among individuals.

Suppose that at the first decision point a very large bonus is paid to increase the retention rate. This will increase the returns to staying with the military for one more term, and many individuals who would otherwise leave will stay. However, those who would have stayed even without the incentive of this large bonus will have an even higher taste for the military than those who were induced to stay with the bonus. Therefore, the average tastes for those who stay with the military will be less when more people are induced to stay because of a large bonus. At the next decision point the people who stayed with the military for the large bonus will be more likely to leave than those who would have stayed without the bonus. Hence, past compensation policies (in this case a large bonus in the previous term) will affect current retention. Second, people with greater tastes for the military are less sensitive to changes in military pay than people with lower tastes. Failure to estimate the separate effects of cost of leaving on the retention behavior of people with different tastes will cause underprediction of the effects of military pay changes at the earlier years of service and overprediction at the later years of service, because the average tastes increase with years of service. The retention models vary in their ability to capture the effects of tastes on retention rates.

### Random Shocks

If there were no random shocks, then each member of the cohort who has the same taste for military life and who faces the same military and civilian income opportunities would make the same stay/leave decision. Typically, after the first decision point, cost of leaving increases until the 20th YOS because of the retirement system. An individual's taste for military life is unlikely to change and his financial incentives to stay are increasing, so those who stay at the first decision point will have no reason to leave until YOS 20 unless there are random shocks. But there are losses after the first decision point. Retention models vary in how they incorporate random shocks into the models. Most of them treat random shocks in the error term of a regression equation. This implicitly assumes that although the random shocks affect individual decisions at each decision point, the individuals persist in behaving as if there would be no more random shocks in the future. The DRM captures the random shocks more explicitly as an integral part of the model, thereby assuming that individuals incorporate the possibility of future random shocks in their current decisions.

## MODELS OF RETENTION BEHAVIOR

This section describes the most commonly used behavioral retention models and discusses their theoretical limitations. Succeeding sections evaluate the practical importance of these limitations.

The models will be explained in the following order: the present value of cost of leaving (PVCOL) model, the perceived pay model (PPM), the annualized cost of leaving (ACOL) model, and the dynamic retention model (DRM). For the technically oriented reader, Appendix A provides a mathematical description of these models. They differ in how they deal with the uncertainties in the military and civilian income opportunities, the sequential nature of retention decisions, tastes, and random shocks. They also differ in the input requirements for estimation and prediction.

### The PVCOL Model

An individual who faces a stay/leave decision at the end of a term has the following options: (1) He can leave now to start receiving civilian pay until the end of his working life and whatever civilian pensions he may be eligible for in his civilian retirement years; (2) he can stay in the military for another term and then leave to receive military pay for one more term and start receiving civilian pay thereafter; (3) he can stay in the military for two more terms; (4) and so on, until he stays in the military for the maximum allowable period of 30 years. If he leaves at any of the decision points and if he is eligible for military retirement pay, he will be receiving the already vested military retirement pay for the rest of his life in addition to the civilian pay. Therefore, the individual must evaluate the income stream from leaving now and all the possible future income streams. The PVCOL model assumes that these income streams (or their expected values) are known with certainty. It also assumes that the individual's implicit discount rate is known. Thus, the current value of future income can be calculated. Then, in this model, the present value of each of the income streams is evaluated. A separate cost of leaving is calculated for staying until the person reaches each of the future decision points by subtracting the present value of the income stream from leaving now from the present value of staying until the relevant future decision point and then leaving. PVCOL assumes that the *maximum of these is the relevant cost of leaving.* In other words, PVCOL is a maximum regret model.

The assumption that future income streams (or their probability distribution) are known with certainty negates the need to update them as each of the future decision points is actually reached. This enables utilization of a dynamic programming approach in calculating the present value of cost of leaving, which simplifies the computational requirements. That is, one can start computing the present value of leaving at YOS 30, which is the last YOS before mandatory retirement. Then, to evaluate the cost of leaving at the preceding decision point, say at YOS 29, all that is necessary to compute is the present value of leaving at YOS 29, because the present value of staying until the next decision point can be obtained simply by discounting the present value of leaving at YOS 30 by an additional year. Continuing this procedure, in earlier years of service the present value of staying until each of the possible future decision points would not require recomputation, but only discounting for an additional year. The dynamic programming approach is also used in other models because they all make the same assumption about the future income streams.

Different military and civilian income opportunities can be specified for different subgroups of a cohort. It is assumed that if the cost of leaving measure plus the random shock appropriate for the individual is greater than zero, he stays; otherwise he leaves military service. In different applications, the probability distribution of the random shocks are assumed to be normal or logistic. If a logistic distribution[13] is specified, then the parameters of the model are estimated by using the following equation:

[13]The logistic regression ensures that retention rates are bounded by zero and one. Also, the elasticities of responses to pay changes decline when the retention rates are closer to one (or zero), which seems to be realistic.

$$r_i = 1/\left[1 + e^{-(\alpha_0+\alpha_1 \mathrm{pvcol}_i)}\right] \qquad 2.1$$

where $r_i$ is the retention rate at the decision point i,

$pvcol_i$ is the cost of leaving at the decision point i,

$\alpha_0$ and $\alpha_1$ are the parameters to be estimated.

A major limitation of the PVCOL model is that it does not model tastes. Therefore, it is subject to omitted variables bias. The present value of cost of leaving increases with years of service (at least until retirement eligibility). The average value of tastes, the omitted variable, also increases with years of service because of the self-selection process at each decision point. Both increasing tastes and increasing cost of leaving lead to higher retention, so ignoring tastes will lead to a positive bias in the estimate of the effect of cost of leaving. Hence, on this ground, predictions by this model are likely to overpredict the effects of pay changes on retention rates. Also, estimating a constant effect of cost of leaving across years of service will lead to different biases in different years of service. Furthermore, this model cannot relate the effect of past compensation policies to current retention rates.[14]

PVCOL is a maximum regret model, so compensation policy changes that do not effect either the optimal time to leave or the present value of leaving at the optimal time will be predicted to have no effect on the retention rate. For example, PVCOL will predict no change in the retention rates at the early decision points, even for such a drastic change in the retirement system as to limit retirement benefits to 50 percent of the basic pay regardless of years of service after YOS 20. At the early years of service, the best year to leave is usually YOS 20 (depending on the assumptions); and this policy keeps the retirement benefits unchanged at YOS 20.

[14]This concept will be discussed in more detail under the ACOL model.

Finally, in the PVCOL model the random shocks are modeled only in the error term. Individuals persist in behaving as if the current shock will be the last and do not consider the possibility of random shocks in their decisionmaking until they face them. This is one of the reasons why PVCOL can focus on a single future decision point in calculating the cost of leaving measure.

### The Perceived Pay Model

The PPM, like the PVCOL, calculates the present value of leaving at each of the future decision points and the present value of leaving at the current decision point. But in calculating the returns to staying, it does not focus on a single future decision point. Rather, it uses a weighted average of the present values of staying until each of the future decision points. The weights are an individual's probability of remaining in the military until the relevant future decision points. This probability is assumed to be equal to the probability of retention for all individuals.[15] The perceived pay is defined as the weighted average of the present value of staying until each of the future decision points, divided by the present value of the income stream from leaving immediately.[16] Then this cost of leaving measure is related to the retention rates by means of a logistic supply function.

To reduce the bias of not explicitly incorporating tastes in the model, a proxy for tastes is included. The proxy is the cumulative probability of leaving the military until the current decision point, because it is highly correlated with the mean of the censored taste distribution of the cohort. This methodology requires knowledge of the future retention rates to weight the present value of staying until each future decision point, so a dynamic programming approach is used to calculate the perceived pay. The parameters of the model are estimated by using the following equation:

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[15]This formulation was suggested in a study of military retention, Jaquette and Nelson (1974).

[16]Therefore, the perceived pay variable is unitless and its coefficient will be independent of the units of measurement of pay.

$$r_i = 1/\left[1 + e^{-(\alpha_0+\alpha_1 pp_i+\alpha_2 cumrt_i)}\right] \qquad 2.2$$

where $r_i$ is the retention rate at the decision point i,

$pp_i$ is the perceived pay at the decision point i,

$$cumrt_i = 1 - \prod_{t=1}^{i-1} \qquad 2.3$$

$\alpha_0$, $\alpha_1$, and $\alpha_2$ are the parameters to be estimated.

The taste proxy requires knowledge of the cumulative probability of leaving before the current decision point. An iterative approach is required to predict the effects of compensation policy changes. In the first iteration, present continuation rates are used as the starting value for the taste proxy. Then the predicted rates are substituted until the subsequent predictions from the model converge.

The first limitation of this model is due to the weighting scheme. Because predicted retention rates are used in weighting the future returns, the weights represent the probabilities for those who choose to stay at the current decision point, not the probabilities for those who choose to leave. Those who choose to stay have, on average, higher probabilities of remaining in the military until future decision points than those who choose to leave. PPM is therefore likely to overstate the effects of future pay changes on current retention rates. However, because the effect of perceived pay is constrained to be constant across years of service,[17] there will be different biases at different years of service. Finally, as in PVCOL, the random shocks are treated in the error structure of this model. Hence, individuals receive random shocks each period, yet they behave as if the current shock is the last one they will receive.

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[17]Actually a separate coefficient is estimated for pre-retirement eligibility years and for YOS 20 to 30. But the biases will still be different between decision points that were lumped together, especially at the early decision points where the censoring effect is the strongest.

## The ACOL Model[18]

The ACOL explicitly introduces a taste factor into the model. It assumes that there is a monetary equivalent value of tastes and incorporates that value into cost of leaving calculations. Individuals who have a great taste for military life will have higher costs of leaving than those who face similar financial incentives but have less of a taste for military life. Furthermore, the longer a high taste individual stays with the military, the higher the monetary value he will place on his tastes for military life.

The first step in calculating the cost of leaving measure for the ACOL model is to obtain the present value of the cost of leaving for each decision point, just as in the PVCOL model. Then the annuity equivalence of the present value of the cost of leaving is computed over the horizon between the current decision point and a future decision point. This value is called the annualized cost of leaving. It is the net amount forgone in pay for each year between the current year and a future decision point, if the individual leaves military service rather than staying until that decision point. The problem of determining the appropriate time horizon for staying is resolved by choosing the future decision point that gives the maximum ACOL value. If that value plus the annual monetary value of his tastes is positive, then the military is offering him more money than his valuation of civilian income and civilian employment. If that sum equals zero, then the individual is just on the margin between staying and leaving. If it is less than zero, the individual would leave.

This formulation of the cost of leaving measure is different from the one in the PVCOL model; it implicitly incorporates tastes. A hypothetical example will illustrate the differences between the two formulations. Let the implicit discount rate be equal to zero. Also let the present value of staying in the military and then leaving at YOS 4, 8, 20, and 24 be \$10, \$16, \$42, and \$40 respectively. In the PVCOL

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[18]For other descriptions of this model, see Warner (1981) and Smoker (1984).

formulation the cost of leaving measure for those who are at YOS 4 will be the maximum of \$16-\$10, \$42-\$10, and \$40-\$10, which is \$32 if they stay until YOS 20. In the PVCOL model this value, \$32, is related to the observed retention rate at YOS 4 by means of a supply function, but there is no theoretical explanation for the differences of behavior among individuals who face similar military and civilian income opportunities.

The ACOL model recognizes that individuals differ in their tastes toward military life. Furthermore, it assumes that these differences are persistent over time and a monetary value can be assigned to the value individuals place on staying in the military for each year. In the ACOL model, the cost of leaving measure for those who are at YOS 4 is the maximum of (\$16-\$10)/(8-4) = \$1.5, (\$42-\$10)/(20-4) = \$2, and (\$40-\$10)/(24-4) = \$1.5, which is \$2 per year.[19] Therefore, according to the ACOL model those with an annual taste value of greater than -\$2 will stay and others will leave at YOS 4.

This formulation of costs of leaving makes the measure of financial incentives directly comparable to the annual monetary value of tastes. Unfortunately, tastes cannot be observed directly. Yet the higher the value of ACOL, the higher will be the retention rates. If the tastes in a cohort are distributed according to a particular probability distribution, the calculated ACOL values can be related to observed retention rates to estimate the effects of compensation changes on retention rates. Usually, tastes are assumed to be distributed logistically and the parameters of the model are estimated by using the following equation:

$$r_i = 1/\left[1 + e^{-(\alpha_0 + \alpha_1 \mathrm{acol}_i)}\right] \qquad 2.4$$

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[19]The "best" future decision point is not necessarily the same in the PVCOL and ACOL models. For example, if in this example the present value of staying until YOS 8 and then leaving was \$19, then the best future decision point for the ACOL model would have been YOS 8, rather than YOS 20--i.e. (\$19-\$10)/(8-4) = \$2.25 > (\$42-\$10)/(20-4) = \$2.

where $r_i$ is the retention rate at the decision point i,

$acol_i$ is the annualized cost of leaving at the decision point i,

$\alpha_0$ and $\alpha_1$ are the parameters to be estimated.

The first limitation of the ACOL model is that it cannot predict the censoring of tastes over time because of self-selection.[20] The statistical methodology to estimate the parameters of the model implicitly assumes that individuals' tastes change at each decision point.[21] This assumption breaks the link between compensation policies in one period and retention rates in the next. When tastes are assumed to be logisticly distributed, $\alpha_0$ is proportional to the mean of the taste distribution and $\alpha_1$ is inversely proportional to the standard deviation of the tastes in a cohort. After the first decision point, if people with low tastes leave, then the mean of the truncated distribution will be higher and the standard deviation will be smaller (i.e., the remaining people will be more homogeneous in their tastes toward military life and their tastes will be higher than the average tastes for the entering cohort). Therefore, the parameters of the model will not be constant over time because of self-selection. Furthermore, the shifts in the parameters will be a function of the past compensation policies, which influenced the self-selection effects in the past. In estimation, if the parameters are assumed to be constant across years of service, then the ACOL model will have different biases in different years of service. In particular, the decrease in the standard deviation of the taste distribution with years of service is likely to increase the coefficient $\alpha_1$. But if a single $\alpha_1$ is estimated across years of service, the retention effects of compensation changes at the earlier

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[20]As individuals make voluntary stay/leave decisions over time, those who stay are more likely to have greater tastes for military life than those who leave.

[21]The calculation of the ACOL values assumes that tastes persist over time. Therefore, there is an internal inconsistency in the model as it has been applied. This point has been identified by Gotz and McCall (1984).

years of service are likely to be overpredicted and the retention effects at the higher years of service are likely to be underpredicted.

Realizing this problem, some users of the ACOL model make an ad hoc adjustment to the model by adding a YOS variable to the model when it is estimated.[22] This is intended to capture the increase in the mean of the taste distribution with years of service. However, the estimate of the coefficient of the YOS variable will reflect the particular censoring pattern that gave rise to the data used in estimating the model. Therefore, when this model analyzes major shifts in the retention patterns, the predictions will not be sensitive to the new censoring patterns of the tastes. Although this adjustment may be adequate in analyzing retention effects of minor changes in compensation, it is less likely to be adequate when major changes are analyzed.

The inability of the ACOL model to follow the self-selection effects has been identified in previous studies,[23] but ACOL has a limitation that introduces biases in the opposite direction: It does not explicitly model the effects of random shocks on retention decisions. ACOL focuses only on those who are on the margin of staying and leaving when only their tastes and financial incentives are considered.[24] But as discussed earlier, uncertain events may influence retention decisions as well. Therefore, some individuals with very great tastes for the military may leave because of a large negative random shock and some individuals with very little taste for the military may decide to stay because of a very large positive random shock. Therefore, everyone is on the margin of a stay/leave decision.[25]

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[22]Either YOS dummies or log of YOS are used in different applications. The QRMC V model used a YOS dummy to indicate the first five YOS.

[23]See for example, Warner (1981); Gotz and McCall (1984); and Fernandez, Gotz, and Bell (1985).

[24]This is an improvement over the PVCOL model, which assumes away the existence of tastes and examines only those who are taste neutral between civilian and military life.

[25]Each person has a probability of leaving that is greater than zero. Those with greater tastes for military life are likely to have lower probabilities of leaving than those with lesser tastes.

Describing the estimation of the parameters of an ACOL model will clarify the explanation of the biases caused by ignoring random shocks. Assume that the mean of the taste distribution is known and one is trying to estimate the standard deviation of the taste distribution by examining the first decision point. Given an observed retention rate at the end of the first term of enlistment, estimation of ACOL is equivalent to (1) assuming a functional form for the taste distribution, (2) calculating cost of leaving from financial incentives, and (3) asking what value of the standard deviation of the taste distribution makes the proportion of airmen with taste values greater than the negative of annualized cost of leaving (-ACOL) equal to the observed retention rate? If there were no random shocks,[26] this procedure will estimate the standard deviation of the taste distribution correctly.

Assume that the parameters of the taste distribution are known and observe what will happen to the retention rate if random shocks are introduced. The retention probabilities at the first decision point are usually less than 0.5, so adding the influence of random shocks will increase the proportion of airmen that are staying.[27] Some individuals with tastes lower than -ACOL will stay and some with tastes higher than -ACOL will leave, but more individuals would have left without the random shocks than would have stayed. Because random shocks could change the decisions of individuals who are the same distance away from -ACOL with equal probabilities, and there are more individuals who have taste values that are less than -ACOL than with greater than -ACOL, the random shocks will increase the retention rate at the first decision point (see Fig. 1).

In the estimation of the standard deviation of the taste distribution in an ACOL model, the higher the retention rate the higher will be the estimate of the standard deviation. If the distributional form and the mean of the taste distribution are known, then to have a higher probability in the right-hand tail of the distribution (probability of tastes being greater than a specified level (-ACOL)) the standard deviation of the distribution should be higher too.

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[26]And if the functional form and the mean of the taste distribution were known.

[27]For a mathematical proof of this point see Appendix A.

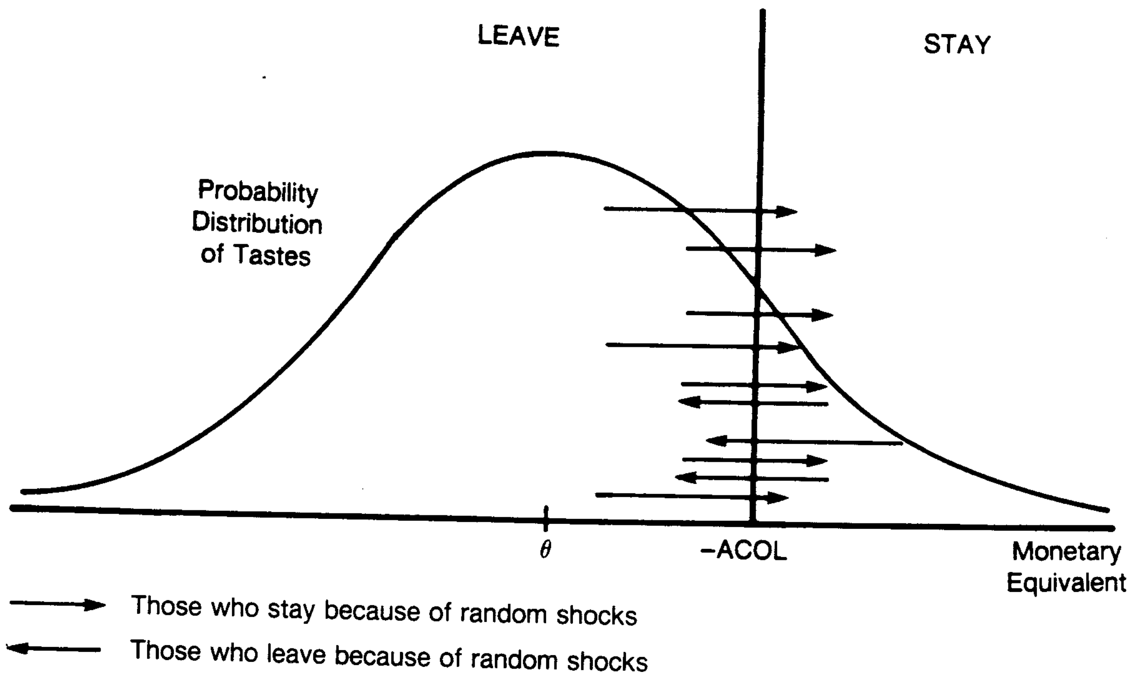


Fig. 1 -- The effect of random shocks on the first term retention rate[a]

[a]Because the probability distribution of tastes is a symmetric, unimodal probability distribution around its mean $\theta$, and the retention rate without random shocks is less than 0.5 (i.e., $-ACOL > \theta$ ), the introduction of random shocks increases the retention rate. (See Appendix A for a proof.)

Therefore, if the random shocks actually influence retention decisions, the ACOL model's estimate of the standard deviation of the taste distribution will be higher than the actual standard deviation. Because the coefficient of the ACOL variable is inversely proportional to the standard deviation of tastes, the sensitivity of the retention rates to ACOL will be underpredicted. When a retirement policy change that reduces the ACOL values is considered, the potential reduction in the retention rates will be predicted to be smaller than the actual changes.[28]

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[28]This effect is explained only at the first decision point and with the assumption of known mean for the taste distribution. Obviously, the mean of the taste distribution has to be estimated too. Therefore, ignoring random shocks will bias that parameter's estimation as well. Furthermore, the argument becomes more difficult through years of service (it becomes conditional on -ACOL values at subsequent decision points). Quantifying the importance of these kinds of biases is one of the objectives of the simulation methodology.

Ignoring the existence of random shocks leads the ACOL model to assume that two income streams with the same annuity equivalences will have the same retention effects regardless of the differences in length of time required to realize the benefits in each stream. But the longer an individual has to wait to realize the benefits of an income stream, the higher will be the probability of receiving a large random shock that may induce him to leave and not be able to receive those benefits.

The third limitation of the ACOL model is that it is a maximum regret model and therefore does not predict any retention effects for pay changes that do not affect maximum ACOL value and the time horizon over which ACOL values are maximized. But when the time horizon changes, abrupt retention effects may be predicted. For example, the ACOL model will predict a major reduction in the retention rates at YOS 16 even for a hypothetical retirement policy change that increases the eligibility to 24 YOS while keeping the discounted benefits under the new policy equal to the discounted benefits under the current policy. If the discount rate is zero, the ACOL measure will be halved,[29] implying a major reduction in the retention rate at YOS 16. This policy change will reduce the retention rates, but probably not as much as the ACOL model will predict.

In the ACOL model individuals are assumed to know their future military and civilian income streams with certainty. Usually in applications, the median promotion path is used to calculate the military income streams. However, this assumption prevents the model from analyzing the effects of compensation policy changes separately for different grades. For example, in the analysis of changing the base pay in retirement pay calculations to the average of highest three years' base pay, the ACOL model predicts no change in the retention rates at the early years of service because the time horizon at the early decision points is usually YOS 20 with a median grade of E-6 for enlisted airmen.[30] Also, according to the median promotion path, they

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[29]Under the new policy the same cost of leaving will be annualized over 8 years rather than 4. Also, discount rates other than 0 percent would not change the argument materially.

[30]Even if the ACOL model was not a maximum regret model, using a median promotion path would be a problem in analyzing policy effects that vary by grades.

will be promoted to this grade more than three years before retirement eligibility, and the base pay for E-6s in YOS 18 to 20 is constant. Although the "high-three-years base pay" policy changes the retirement pay calculations for some individuals, the ACOL model will predict no changes in retention in the early decision points because this policy will not affect the median individual. This is more a problem of application than a limitation of the model and can be corrected simply by using probability of promotion in military pay calculations rather than assuming everyone follows the median promotion path. However, that will complicate the model.

### The Dynamic Retention Model[31]

The DRM is theoretically the most rigorous and consistent of the existing retention models. The two salient limitations of the previous models were related to: (1) the way they determined the appropriate time horizon for calculating the returns to staying, and (2) the way they modeled tastes. In addition, the previous models were limited in the way they could analyze the effects of promotion policies on retention decisions.

The DRM explicitly models the promotion process, which reflects a part of the uncertainty about the future military pay. Therefore, the effects of changes in the promotion opportunities, timing, and HYT policies on retention decisions can be analyzed.

The DRM also assumes individuals recognize that random shocks may change their future behavior. Therefore, they cannot know when they will leave military service with certainty. In calculating returns to staying, the DRM does not focus on a single future decision point, but uses a weighted average of the present values of staying until each of the future decision points. Just as in the PPM, the weights are an individual's probability of remaining in the military until a future decision point. But unlike the PPM, the DRM recognizes that each individual's probability of remaining in the military depends not only on civilian and military income streams but also on the possibility of

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[31]For a more detailed nontechnical description of this model see Fernandez, Gotz, and Bell (1985).

random shocks and on his taste value. In the DRM, individuals are assumed to know the monetary value of their tastes and the probability distribution of random shocks. In other models the random shocks are treated as a part of the error term; in the DRM, they are an integral part of the model. For example, the model recognizes that individuals are more likely to stay today if they know that they can avoid receiving large negative random shocks, say undesirable assignments, by leaving the military in the future.

The DRM recognizes that individuals differ persistently in their tastes for military life and incorporates the monetary value of their tastes in the model's cost of leaving calculations. Because the taste values of individuals cannot be observed explicitly, calculations of cost of leaving require inferences about the distribution of tastes among the members of a cohort.[32] Therefore, the DRM uses a different estimation approach from the previous models.

The DRM specifies distributional forms for the random shocks and the tastes among the members of a cohort at the time of their entry to the military. It also assumes that these distributions are the same across cohorts, that individuals know their taste values, the value of the random shock they receive at the current period, and the probability distribution of the future random shocks. Rather than relating independently calculated cost of leaving measures to the observed retention rates, the DRM directly estimates the parameters of the distribution functions of the random shocks and tastes. First it calculates cost of leaving measures at each decision point for representative individuals with a broad range of taste values. Then the estimation procedure boils down to finding out the proportion of the cohort that has the same taste value as each of the representative individuals for whom the cost of leaving was calculated.[33] Because tastes are assumed to follow a specified distributional form, estimating

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[32]Calculations of taste-dependent continuation probabilities also require inferences about the distribution of tastes among the members of a cohort.

[33]For those who have tastes that are not exactly equal to the tastes of the representative individuals, costs of leaving can be calculated by interpolation.

the parameters of the taste distribution is equivalent to finding out the proportion of the cohort for each taste value. The parameters of the model are estimated by maximum likelihood methods, where the likelihood measure is the probability that the model attaches to the observed events for a given set of parameters.

The estimation procedure is further complicated because the cost of leaving measure in the DRM is also a function of the variance of the random shocks and individuals' implicit discount rate. That is, the probability of an individual staying until a particular future decision point is the probability that his cost of leaving, which includes his taste, will be greater than the random shock he will receive.[34] Because by assumption he does not know the value of future random shocks, but he knows their probability distribution, he has to calculate the probability of remaining in the military until each future decision point. Also according to the DRM, the probability of remaining in the military is crucial in weighting returns to staying until each of the future decision points. Therefore, inferences about the variance of the random shocks and the implicit discount rates are incorporated in the COL calculations by specifying the values for the variance of the random shocks and the discount rate, estimating the parameter values for the taste distribution that gives the best maximum likelihood fit to the data for these specified values, and then repeating this process for different values until there is a satisfactory fit to the observed data.

Three major limitations of the DRM are related to the complexity of the model. First, its estimation is difficult and costly. Second, adding variables to the model that may affect individuals' retention decisions (e.g. civilian unemployment) will further increase the difficulty of estimation. Third, the data requirements for estimation are greater than for other models.

The versatility of the model and its consistent treatment of the self-selection effects exact a cost in increased difficulty of estimation. The cost of leaving measure cannot be evaluated

[34]In the DRM, even individuals with high tastes for the military could leave if they receive a large enough negative shock. Therefore, it is necessary to calculate the costs of leaving for representative individuals with a broad range of tastes.

independently from the estimation of the model's parameters. The DRM was applied in predicting retention decisions of officers, and the estimation in that case was difficult. Although theoretically there is nothing inherent in the model to restrict its use in predicting retention decisions of enlisted personnel, enlisted personnel are likely to be more heterogeneous in their tastes toward the military; and different occupational groups may face different random shock distributions. This will make the estimation even more difficult because the estimate of the taste parameter will capture not only individual differences in valuation of nonmonetary factors, but also differences that may have been measured inaccurately. For example, to the extent measurement errors in civilian income opportunities are constant over time, they will be captured in the parameter estimates of the taste distribution.[35] Therefore, the model may have to be estimated separately for different subgroups of enlisted personnel. This will add to the difficulty of estimation.

Although theoretically possible, incorporating additional variables that may influence retention decisions is actually very difficult because additional variables will further complicate the already difficult estimation process. For example, the DRM does not explicitly model the role of civilian unemployment, which certainly affects retention decisions (Argüden and Carter, 1984). Expected civilian earning streams are constructed by multiplying the civilian earnings estimates by one minus the unemployment rate. This formulation will not capture the differential effects of unemployment rates on retention rates at different decision points.

The DRM assumes that taste distribution is the same across cohorts. The level of recruitment efforts, the size of an entering cohort, or the state of the civilian economy may influence the types of individuals who enlist for military service in different years, thereby influencing the distribution of tastes across cohorts. But changing the assumption of constant tastes across cohorts requires estimating the pattern of

[35]Although this will make the model more robust to errors in estimated civilian earnings, to the extent these errors do not remain constant in the prediction period, the DRM predictions may be biased.

changes, which in turn requires estimation of additional parameters.[36] From a policy analysis perspective, analysis of differential retention effects of changing compensation policies by personnel quality may be desired.[37] This, too, will require either separate estimations of the DRM by different quality groups or addition of new variables to the model.

Estimation of the DRM requires longitudinal data that are more difficult to collect and use than cross-sectional data. However, estimation of self-selection effects cannot be done without such data.[38]

Despite its estimation difficulties, predictions by the DRM are fairly easy to obtain. Once the parameters of the model are estimated, simple simulations will provide the estimates of the retention effects of many compensation policy changes. The dynamic nature of the DRM's predictions relate the effects of past compensation policies and expected future policies to current retention rates and require a simulation model because the DRM's parameter estimates are not average responses of military personnel to different compensation policies, but describe the environment and preferences of military personnel. The DRM's predictions depend on those members of an entering cohort who are still in the military to make retention decisions. Therefore, different predictions will be made for cohorts who face different historical compensation policies.

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[36]Even if the tastes were distributed similarly across cohorts over the estimation period, changing the retirement system in a major way may influence the accessions and therefore the tastes distribution of new cohorts. But because only about 10 percent of an entering cohort stays until retirement eligibility, this problem has limited practical importance.

[37]For an operationalization of the concept of "quality" by looking at such observable characteristics as education level, AFQT scores, and promotion speed, see Ward and Tan (1984).

[38]The Defense Manpower Data Center (DMDC) has longitudinal data on retention decisions of individuals who have been in military service since 1971. Although there are gaps in the retention decisions of personnel who entered the military before 1971, the data problem is not insurmountable. In addition, DMDC continues to collect reliable data on military personnel. Therefore, as time passes, the data problem will become less important.

## SUMMARY

Behavioral models of retention incorporate four factors with varying degrees of success: military income opportunities; civilian income opportunities; persistent differences among individuals that influence their valuation of nonpecuniary benefits of military and civilian life (tastes); and such events as sickness in the family that may influence individuals' retention decisions (random shocks).

All models assume that retention decisions are influenced not only by current military and civilian compensation levels, but also by life cycle income opportunities offered in these sectors. The models calculate a measure of cost of leaving that is the difference between the value of staying in the military for at least one more term and the value of leaving the military at the current decision point. Then this measure is related to the observed retention rates to estimate the sensitivity of military personnel to compensation levels. Because the military personnel system is essentially a laterally closed system, those who leave usually do not come back. Therefore, the value of leaving is straightforward to calculate. But those who stay at a particular decision point will have to make other stay/leave decisions at the future decision points (each time their contracts are up for renewal). One of the major differences among retention models originates from the way they decide which future decision point to focus on or how they weight the values of staying until different future decision points.

Of the four factors that are incorporated in these models, military and civilian income opportunities are directly observable (despite the difficulties of doing so), but tastes and random shocks are not. The most important differences among the retention models are caused by the approaches they take in modeling tastes and random shocks. At least in theory, inadequate modeling of these unobservable factors could lead to biases.

No one model is the best in ease of estimation, theoretical rigor, and predictive capability. Therefore, in the past all of the models have been used and some of them are still being used by the military manpower community. The PVCOL model is no longer in use because of the limitations described here. The Congressional Budget Office has used the PPM model in analyzing military retirement policies. Despite its theoretical limitations, the ACOL model is the most commonly used model by the services and the DoD for the analysis of long term compensation issues because of the ease of its estimation. The DRM is the theoretically most rigorous model, but its estimation difficulties have lessened its acceptance by the military manpower community.

# III. A SIMULATION METHODOLOGY TO EVALUATE ALTERNATIVE RETENTION MODELS[1]

The main purpose of using retention models in analysis of alternative retirement systems is to evaluate potential changes in force profiles. Therefore, the best criterion to choose between models should be how well they can predict retention effects of policy changes. However, there have been no great changes in the retirement system in the recent past, so there are no empirical data available for us to use in applying this criterion. Previous comparisons of various models concentrated on their fit to observed retention patterns, their theoretical rigor, and on how well they can predict the effects of minor changes in military compensation (Warner, 1981; and Fernandez, Gotz, and Bell, 1985). But good fit to data does not guarantee accurate predictions, theoretical comparisons are not conclusive in determining the practical importance of identified limitations, and a model that can predict minor changes in retention rates accurately may not be able to predict the effects of major changes in the retirement system.

The approach here is to simulate an environment in which different retention models can be evaluated according to how well they can predict the retention effects of alternative retirement policies.[2] That is, airmen retention decisions are simulated under the current retirement system. Then, with these simulated data different models are estimated and predictions made for alternative retirement policies. Finally, these predictions are compared with the simulation results under other retirement policies. Of course, this methodology actually evaluates the performance of different models with respect to the simulation model. Therefore, the closer the simulation model is to reality the more appropriate the evaluations will be. The simulation model used here was calibrated using data from 1971-1981, and it tracks actual retention rates over that period hearteningly well.[3]

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[1]I wish to thank my chairman, Michael Murray, for his intellectual support in developing this methodology.

[2]Such an approach was used in Ignall, Kolesar, and Walker (1978)

[3]The calibration of the model is described at the end of this section.

Because the DRM is the most complete model in its representation of the major factors influencing retention decisions its theoretical framework is taken as the basis of the simulation model. It is theoretically rigorous and logically consistent, and its assumptions are clearly stated. Many behavioral retention models, including the most commonly used ACOL model, are special cases of the DRM; once its parameters are known, the DRM can easily be used in a simulation mode.

All the models that were explained in Sec. II assume rational economic behavior by the agents. Furthermore, with varying degrees of success the models incorporate the same factors. Therefore, with the simulation methodology outlined above, the theoretical limitations of the other models can be quantified in comparison with the DRM. If these limitations are practically unimportant--that is, if the simpler models can predict the effects of simulated policy changes--then they can be used in policy analysis instead of the DRM. If the limitations are important, then the simpler models can be adjusted to provide better predictions. The simulation methodology provides a test bed to see whether adjustments really improve the simpler models. If the simpler models cannot be improved adequately, then the extent of the biases in these models provide an evaluation of what is to be gained by estimating the more difficult DRM. Finally, even if a DRM model is not estimated, this methodology provides information to bound the biases in simpler models. In sum, the simulation methodology permits quantification of the theoretical limitations of the simpler models.

Aside from providing the much missed variation in retention rates under different retirement systems, the simulation methodology enables evaluation of the importance of different inputs to the behavioral retention models. For example, in a simulation world we can know the exact discount rates individuals use for their decisions. Then we can estimate the retention models by assuming other discount rates and evaluate the effects of errors in discount rate assumptions both in estimation and in predictions. Similarly, in a simulation world we know the actual civilian opportunities individuals face. Therefore, we can evaluate the effects of errors in measuring civilian opportunities.[4]

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[4]Such evaluations are presented in Sec. V.

To make sure that the simulation methodology reflects reality as much as possible, special attention was paid to the preparation of inputs. This section explains the assumptions and the inputs to the simulation model.[5] Also, the simulation model was calibrated with the retention rates that were observed in the period 1972-1981 for the enlisted members of the Air Force, which is also explained in this section.

## INPUTS TO THE SIMULATION MODEL

Computation of the financial returns to staying and leaving at different decision points requires various inputs: military pay schedule; special pay (e.g. bonuses); promotion probabilities; civilian income opportunities; growth of military pay, consumer price index (CPI), and civilian income over calendar time; survival probabilities; and individuals' rate of time preference, or implicit discount rates.

### Military Pay Schedule

Military pay is a function of grade, years of service, and fiscal year. Our simulations start with the fiscal year 1981. Basic pay, basic allowances for quarters and subsistence, and regular military compensation (RMC)[6] were obtained from the Uniform Services Almanac for the fiscal year 1981. Fiscal year 1981 pay schedule[7] was taken as the basis for future fiscal years' pay schedules. Military pay was assumed to increase at the same rate as the CPI. That is, the military income opportunities were assumed to stay constant in real terms for years beyond 1981.

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[5]The computer program for the simulations and the values of the inputs that were utilized will be published separately (see Argüden (forthcoming).

[6]RMC is the sum of basic pay, basic allowances for quarters and subsistence, and the tax advantage related to the tax exempt status of the allowances. The tax advantage is the amount of additional taxable earnings required to pay the tax and still be left with the same take home pay. The RMC that was used is an average over tax status.

[7]Pay schedule is the basic pay (which constitutes the basis for bonus and retirement pay calculations) and the RMC for each YOS-grade combination.

Calibration of the simulation model started with the fiscal year 1972. For the fiscal years prior to 1981, the pay schedule was adjusted by using the ratio of military pay at the relevant fiscal year over the pay at 1981, for airmen with grade E-5 and with 6-8 years of service.[8]

## Special Pay

Bonuses are offered to those in certain occupational specialties who are facing a stay/leave decision. If an airman decides to stay at a particular decision point, he receives an amount that is equal to the offered bonus multiple, times the number of years he reenlists for, times his current basic pay. Bonuses were explicitly included in the simulation model. It was assumed that the average bonus multiple for the future fiscal years and the proportion of a cohort that will be offered bonuses will be the same as the averages over the period 1979-1981.[9] In the calibration, all airmen who received bonuses in a given year were assigned the average bonus multiple for that year.

The simulation model differentiates those who receive bonuses from those who do not, but it assigns the same amount of bonus to those who received any bonus at all. Because the majority of the offered bonuses were level one bonuses (the bonus multiple equals one), this simplification is not too far from reality. In the Air Force, bonuses are offered at the first, second, and in very few cases at the third decision points. The simulation model differentiates individuals who are eligible to receive bonuses at the first decision point only, at the first and second decision points, at the second decision point only, and those who are not eligible to receive any bonuses.[10] Therefore, the

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[8]The relationship of military pay and grade-YOS cells remains stable over fiscal years. Therefore, this adjustment is equivalent to using the actual military pay figures from different fiscal years.

[9]The average bonus multiple and and the proportion of airmen eligible for receiving bonuses were calculated from a 10 percent sample of the EAGL file described in Walker et al. (1982).

[10]The Zone C bonuses (bonuses at the third decision point) are not modeled. However, the model is programmed to accept Zone C bonuses by changing the inputs.

retention rates for those who were offered bonuses could be distinguished from those who were not offered any bonuses.

Airmen usually commit themselves to the military for a specific time period, called term of enlistment. Term of enlistment is usually four years; and before retirement eligibility, airmen do not make a stay/leave decision until their term of enlistment is over.[11] In reality, some airmen may leave before their term is over, they can enlist for periods other than four years, and they can extend their current contract for short periods. The simulation model, assumes that everybody makes a decision only at the following years of service: 4, 8, 12, 16, 20, and each year thereafter until YOS 30. For analysis of retirement policies, predicting the number of airmen that will leave military service in a specific four year period, but not exactly the timing within that period,[12] may be adequate. But if the model is used for predicting the changes in the retention rates due to changes in bonuses, the model should be modified to allow predictions of changes in the length of term of enlistment due to bonuses.[13] In the current version of the simulation model, airmen who receive bonuses are assumed to get bonuses for a term of enlistment of 5.5 years, but their actual term of enlistment remains at four years. This is done to obtain the correct amount of bonuses.[14] It will predict the losses at the current

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[11]Although some airmen leave before the end of the enlistment contract, most of the losses occur at the end of the term. That is, attrition losses are much smaller than losses at the reenlistment points.

[12]Whenever loss rates (equal to one minus the retention rate) for each YOS is needed, we smooth the losses at the end of a term over the YOS covered by that term. Smoothing is done by using the observed proportions of airmen who leave before the end of term to the total losses in a term under the current retirement system.

[13]Previous research showed that the major effect of increasing bonuses is lengthening the term of enlistment. See Carter (1985) and Hosek and Peterson (1985).

[14]When bonuses are offered, the average length of term increases to about 5.5 years. See Hosek and Peterson (1985). Because the amount of bonus is related to length of the term, multiplying the bonus multiple by 4 (the fixed length of term in the simulation) will understate the effects of bonuses.

decision point correctly, but the losses (from the group who received bonuses) at the next decision point will be four rather than 5.5 years from the date the bonus was offered.

## Promotion Probabilities

Grade is an important determinant of military pay. Hence, it is an integral part of calculating future income streams. Furthermore, promotions are indications of capability for military service.[15] Airmen move across grades through promotions,[16] which are based on such factors as time in service, time in grade, scores on periodic skill tests, and performance reviews. Time in grade and time in service components imply that the longer an airman stays with the Air Force the higher is his probability of promotion, but those who are more capable are likely to score higher in the skill tests and be promoted earlier than others in their cohort. Taking both of these factors into account, promotion probabilities increase with years of service,[17] but at a declining rate.

The promotion probabilities for the simulation model were calculated from data on promotions of airmen between 1972 and 1981.[18] The promotion probability was defined by the proportion of eligible airmen who were promoted during a particular year of service.

A sophisticated analysis of promotion probabilities would have to deal with predicting the test scores for airmen by using information on entry characteristics such as education level and AFQT test scores, past promotion speeds, and current AFSC.[19] Such an analysis also should keep track of the composition of the eligible population. Pooling data over different years of service should be done very carefully as test scores

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[15] See Ward and Tan (1984) for the relationship between promotion speed and quality of personnel.

[16] Demotions are very rare and are not modeled.

[17] Just before the high year of tenure the promotion probabilities actually decline marginally.

[18] The data were obtained from a 10 percent sample of the EAGL file described in Walker et al. (1982).

[19] AFSC stands for Air Force Specialty Code and describes the occupation of the airmen.

could vary because of random errors, random changes in the difficulty of the tests, and learning effects; and the distribution of test scores could vary because of censoring (best people get promoted), different characteristics of new cohorts becoming eligible in a new year, and size (therefore relative weights) of new and old cohorts making up the eligible population. Such an analysis is beyond the scope of this work. Therefore, average promotion probabilities by YOS are used over different fiscal years and AFSCs.

If time intervals between promotions vary systematically with observable airmen characteristics, using average promotion probabilities will result in underestimation of military earnings for those who can expect to be promoted fastest and overestimation for those who can expect to be promoted slower than average. To evaluate the importance of capturing varying promotion probabilities by groups of airmen, the simulation model assumes that 20 percent of the airmen have promotion probabilities 10 percent higher than the average, for another 20 percent the probabilities are 10 percent lower than the average, and the remaining 60 percent have average promotion probabilities.

### Civilian Income Opportunities

The expectation of military personnel about their potential future civilian earnings influences their decisions about the length of time they serve in the Armed Forces. Therefore, good estimates of expected post-service earnings streams are essential for studying the retention behavior of military personnel.

Servicemen form their expectations about their post-service earnings potentials[20] by using two types of information: the offers they receive and the actual civilian earnings of individuals who are comparable to themselves. Because the offers they receive are not known, analysts use actual civilian earnings of military veterans (or civilians with comparable characteristics) to estimate *expectations* of civilian opportunities among service members. This task is more easily said than done, however. First of all, actual civilian compensation of

[20]Even though their expectations may be different from their actual earnings, their expectations are what they incorporate in their decision to stay or leave.

veterans may differ from potential civilian earnings because of veterans' choices about the number of hours to work and location of employment, which may reduce nominal income but not real income or welfare. Furthermore, in practice it is impossible to identify a control group that is comparable to military personnel in all respects relevant to earnings. Therefore, the estimates obtained in such a manner may be biased to an unknown extent by differences in unobservable characteristics. Even if such a control group could be identified, there are data availability problems on their earnings.

Several studies conducted to estimate the post-service earnings of military personnel[21] have generally concentrated on veterans who served only one term or who retired from the military. There are two main conclusions that can be drawn from these studies. First, military training seems to improve civilian productivity, which in turn improves the civilian earnings of the individuals who leave the military after this training period (usually at the end of their first or second term of service). Second, military personnel who spend 20 or more years in service seem to experience a second career earnings loss--the difference between their post-service earnings and what their civilian earnings would have been had they not pursued a military career--during the transition to a civilian career.[22] This is primarily caused by the difficulty of transferring part of military skills to civilian jobs.

In constructing a "comparable" group to quantify the returns or losses of pursuing a military career in terms of post-service earnings, such factors as years of schooling, age (as a proxy for experience), and perhaps sex and race should be controlled for. This is not sufficient, however. The civilian earnings may also be influenced by one or all of the following factors, which should be controlled for to avoid biases:

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[21]Cooper (1981), Cooper, Gunther-Mohr, and Lewis (1984), Danton (1980), De Tray (1980), Goldberg and Warner (1983), Massell (1975), Norrblom (1971), Norrblom (1977), Zurkowitz (1969).

[22]Cooper, Gunther-Mohr, and Lewis (1984) suggest that this effect is large. Although the argument that experience in military service is not fully transferable to civilian employment is appealing, it is unlikely to be the only reason for the observed earnings loss of personnel who stay in the military for more than 20 years. In particular, those who receive attractive civilian offers are less likely to remain in the military past 20 YOS. If civilian offers are correlated with capability, then the "observed" earnings loss figures will be biased upward for personnel who retire after the 20th YOS.

1. Joining the armed forces is a voluntary decision; it involves a self-selection process--individuals choose to enlist or avoid military service partly by looking at their civilian opportunities.
2. Individuals must pass mental and physical screening processes before they are allowed to serve.
3. Enlistees receive formal training in the military service and their post-service earnings will be influenced to the extent this training improves their civilian productivity.
4. Service in the military may provide civilian employees with information about veterans that may not otherwise be available--such as that they have passed physical and mental tests and met certain standards of behavior and performance to receive an honorable discharge.
5. To the extent armed services experience is transferable to civilian jobs, it will improve an individual's post-service earnings.
6. At the end of each term there is a selection process where those with the best civilian (or worst military) alternatives tend to leave the military.
7. Similarly, by enforcing HYT rules the military could force unsuccessful individuals out.
8. Finally, having served in the military may influence personal preferences related to work such as short work hours or location. In particular, military retirees who receive 50 to 75 percent of their basic military pay as pension will have a positive income effect that increases their demand for leisure.

One of the most recent and comprehensive studies of post-service earnings was prepared for the Fifth Quadrennial Review of Military Compensation by Cooper, Gunther-Mohr, and Lewis (1984). Although there are several problems with that study, to evaluate the performance of different retention models by means of simulation these problems are not important enough to undertake separate analyses of post-service earnings in the limited time available for this study. Instead, their findings for Air Force enlisted personnel are adapted as inputs to the retention models. Cooper et al. did not study the effects of actual post-service earnings of the veterans on expectations of military personnel, but their results can be used if it is assumed that individuals form their expectations by the actual earnings of a control group comparable to themselves in all respects relevant to earnings.[23] Table 3 supports this by indicating that military retirees' assessment of a comparable group's earnings is reasonably good.[24]

Table 3

RETIREES' POST-SERVICE EARNINGS AND SELF EVALUATION OF THEIR PAY: RETIREES WORKING FULL-TIME, YEAR ROUND[a]

| Retiree's Self Evaluation of Their Pay Relative to That of Comparable Nonretirees | Mean of Post-Service Earnings Differentials[b] — Enlisted Personnel: Percent of Sample | Mean of Post-Service Earnings Differentials[b] — Enlisted Personnel: Mean (St.Error) |
|---|---|---|
| Own pay much better | 21.2 | $1,096 (483) |
| Own pay a little better | 16.7 | -292 (563) |
| About the same | 37.0 | -529 (365) |
| Own pay a little worse | 14.2 | -1,598 (588) |
| Own pay much worse | 9.1 | -3,535 (736) |

[a]Obtained from Cooper (1981) Table 19.

[b]The difference between retirees' post-service earnings and the earnings for nonretired veterans, controlling for age, education, race, and region of the country.

[23]QRMC implicitly made a similar assumption by using the Cooper et al. results in their ACOL model. Some of their results were modified for this study.

[24]Although there seems to be a bias to underestimate the comparable group's earnings, the magnitude of this bias is low compared with total earnings, which were in the range of $15,000 (in 1976 dollars).

The main strength of the Cooper et al. study comes from their database, which was developed for the QRMC by the Defense Manpower Data Center (DMDC), the Internal Revenue Service (IRS), and the Social Security Administration (SSA).[25] It has several advantages over previous data obtained through the Census Bureau and mail surveys. It includes, for the first time, information about veterans who left the military at the end of their second term or in their career years before retirement eligibility. Also, it merges post-service salary and wage earnings from IRS/SSA records to military personnel files, which have consistent and reliable information on individuals. Finally, it provides the capability to analyze post-service earnings by DoD occupational groups.

The database has some shortcomings as well. First, the IRS/SSA data include no information on nonwage income, and the IRS sample includes only those individuals with some wage and salary income. Second, the IRS/SSA data do not contain any information on current working status, current education level, variables describing individual preferences, or information about an individual's post-service occupations. Third, for privacy reasons the data were collected with a cell structure. To keep the number of cells down to a manageable level, certain variables describing individual characteristics were constrained to have a smaller number of possible values than would be desirable. For example, the length of service variable grouped several years together in the same cell. The cell structure also necessitated using average values of certain variables within each cell. Finally, the earnings data from the SSA are truncated at the social security reporting ceiling; and data from the IRS were reported up to a confidentiality ceiling of $150,000. This truncation is less of a problem for enlisted personnel than for officers because fewer enlisted veterans have earnings exceeding these limits.[26]

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[25]It is expected to be updated annually and can be a rich source of data to improve on the work of Cooper et al.

[26]See pp. 224-231 in App. Q of QRMC report, V-1, I-C.

Cooper et al. controlled for the usual determinants of wages: age (as a proxy for experience level), education level, sex, and race. Furthermore, they took military veterans as their comparison group, avoiding the biases that could have arisen from choosing a sample from the census population by controlling for the voluntary decision to join the military, the screening process through physical and mental tests, and military training received by all military personnel. They also restricted their sample to include only those who received an honorable discharge. To the extent individuals with dishonorable discharges did not make a stay/leave decision, excluding them is appropriate. Otherwise, their exclusion will bias the estimate of post-service earnings upward because those who separated with dishonorable discharges are likely to receive lower wages in the civilian sector.[27]

They controlled for the differences in military experience by using a YOS variable in their regressions. They further restricted their sample to those who are working full-time and have wage and salary earnings. The exclusion of the self-employed (nonwage-salary earners) is justified because reported earnings of the self-employed tend to be gross income of their business, which includes returns to other factors in addition to the imputed wages of the entrepreneur. Furthermore, the IRS/SSA data simply did not have information on the self-employed. Inclusion of persons who choose to work less than full-time would have understated their potential full-time earnings.[28] There are two reasons for individuals to select out of the full-time civilian labor force. First, their military pension may have a positive income effect to increase the demand for leisure. Second, those who experience a large second career loss may not receive civilian offers above their reservation wages. Those who select out because of the first reason will bias downward the potential post-service income estimates because

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[27]This is worth investigation in future studies because 15 percent of enlisted personnel do not receive an honorable discharge and yet they too are military veterans (QRMC, Vol. I-C, p. 106). Furthermore, they are concentrated in earlier YOS groups.

[28]In other words, full time earnings is a better proxy for the wage rate than average earnings.

retirees with fairly large pensions are those who were productive relative to the average in the military and possibly would have been more productive in the civilian sector as well. However, those who select out because of the second reason will bias the potential post-service earnings estimates upward.

Although one needs to be careful in extrapolating the results obtained from a sample of full-time working veterans to other veterans, such an extrapolation should give reasonable estimates for two reasons. First, the biases described are working in counteracting directions.[29] Second, Table 4 indicates that only 10.5 percent of enlistee retirees voluntarily choose to work less than full-time and Table 5 indicates that those who look for jobs find one in a short period.

The most critical problem with the Cooper et al. study is its failure to correct for selectivity at the end of each term. To the extent that more productive personnel select themselves out at the end

Table 4

ENLISTED RETIREE'S IMMEDIATE POST-SERVICE ACTIVITIES[a]
(Percent)

| Length of Military Career (Years) | Working Full-time | Working Part-time, Looking for Full-time | Not Working But Looking for Work | Working Part-time | Not Working, Not Looking | Going to School |
|---|---|---|---|---|---|---|
| 20-24 | 65.1 | 5.6 | 15.1 | 3.1 | 4.5 | 6.5 |
| 25-29 | 46.5 | 2.6 | 21.4 | 6.9 | 12.5 | 10.0 |
| 30-35[b] | 26.6 | 14.8 | 18.3 | 13.5 | 20.6 | 6.3 |
| All | 61.4 | 5.6 | 16.0 | 4.0 | 6.1 | 6.9 |

[a]Obtained from Cooper (1981), Table 14.

[b]In the Air Force only .04 percent of veterans are in this category.

[29]Although we cannot be sure about their magnitudes, we do not expect them to be very large. For example, the difference in pensions of an airman who leaves at 20th YOS as an E-6 and an airman who leaves at the 25th YOS as an E-7 is about \$4,000/year (\$1249 × 0.50 - \$1522 × .625) × 12 = -\$4000), and the income effect of \$4000 on demand for leisure is expected to be low.

Table 5

MONTHS SPENT LOOKING FOR A JOB
IMMEDIATELY FOLLOWING RETIREMENT[a]

| Length of Military Career (Years) | Mean | Median | 75th Percentile | 90th Percentile |
|---|---|---|---|---|
| 20-24 | 2.2 | 0.0 | 2.0 | 6.0 |
| 25-29 | 2.7 | 1.0 | 3.0 | 6.3 |
| 30-34[b] | 4.8 | 1.0 | 6.0 | 12.0 |
| All | 2.3 | 0.0 | 2.0 | 6.0 |

[a]Obtained from Cooper (1981), Table 15.

[b]In the Air Force only .04 percent of veterans are in this category.

of a term, the estimates for post-service earnings will be biased upward. However, if the separatees consist primarily of those who were forced out by the military, the estimates will be biased downward. Because those who did not receive an honorable discharge (more likely to fall into the forced out category) were excluded from the sample, the net bias is likely to be positive. This would hold more strongly for personnel who served more than one term but separated before retirement eligibility. Those who did not leave at the first decision point would be closer to retirement eligibility and would leave only if they received a very high civilian offer.[30] In fact, loss rates are much lower as individuals come closer to retirement eligibility; therefore, the civilian wages of the few separatees who leave in their career years before retirement eligibility are unlikely to be representative of the civilian earnings potential of the military personnel in their career years. At those decision points where the loss rates are much higher (i.e., at the end of the first-term and at the retirement eligibility

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[30]They may also leave because of a sickness or may be forced out for misconduct or HYT. However, Cooper et al. excluded disabled individuals and those who did not receive a dishonorable discharge, so their estimates are likely to be biased upward.

years), those who are leaving will include the ones with both the best civilian earnings potential and the worst military potentials (who are likely to receive lower civilian offers). Therefore, the average earnings of veterans who leave at those decision points are more likely to reflect the mean civilian earnings potential for personnel who remain with the military. Cooper et al. estimates of past service earnings potential should be reasonably good for those who leave at the end of the first term or at the retirement years and be biased upward for other separatees. Figure 2, which was derived from Cooper et al. estimates for airmen, shows the lifetime civilian earnings potential for "typical"[31] airmen who leave at 4, 8, 12, 16, 20, 23, 26, and 30th YOS (depicted on Figs. 2 and 3 as 1, 2, 3, 4, 5, 6, 7, and 8, respectively). According to these estimates, those who leave before the 20th YOS have similar earnings potential,[32] but if they served 20 or more years, they experience a major second career loss in civilian earnings potential. This trend is implausible, and the selectivity bias described can account for what Fig. 2 shows. In other words, as their retirement eligibility comes closer, only those who receive very high civilian offers would leave,[33] and what we are seeing is the upper bound of the civilian earnings potential for those who leave in 8, 12, and 16 YOS. Because we place higher confidence in the estimates for those who leave at the end of first term or at retirement years, estimates for those years are interpolated to obtain estimates for leaving at 8, 12, or 16 YOS. If we do not interpolate and use Cooper et al. estimates for airmen (as shown in Fig. 2), when we are analyzing different retirement systems we may predict overreaction to certain options. For example, because the civilian earnings potential for 16 YOS would be biased upward, a reduction in retirement eligibility (e.g., to 16th YOS) would unusually increase the loss rates.

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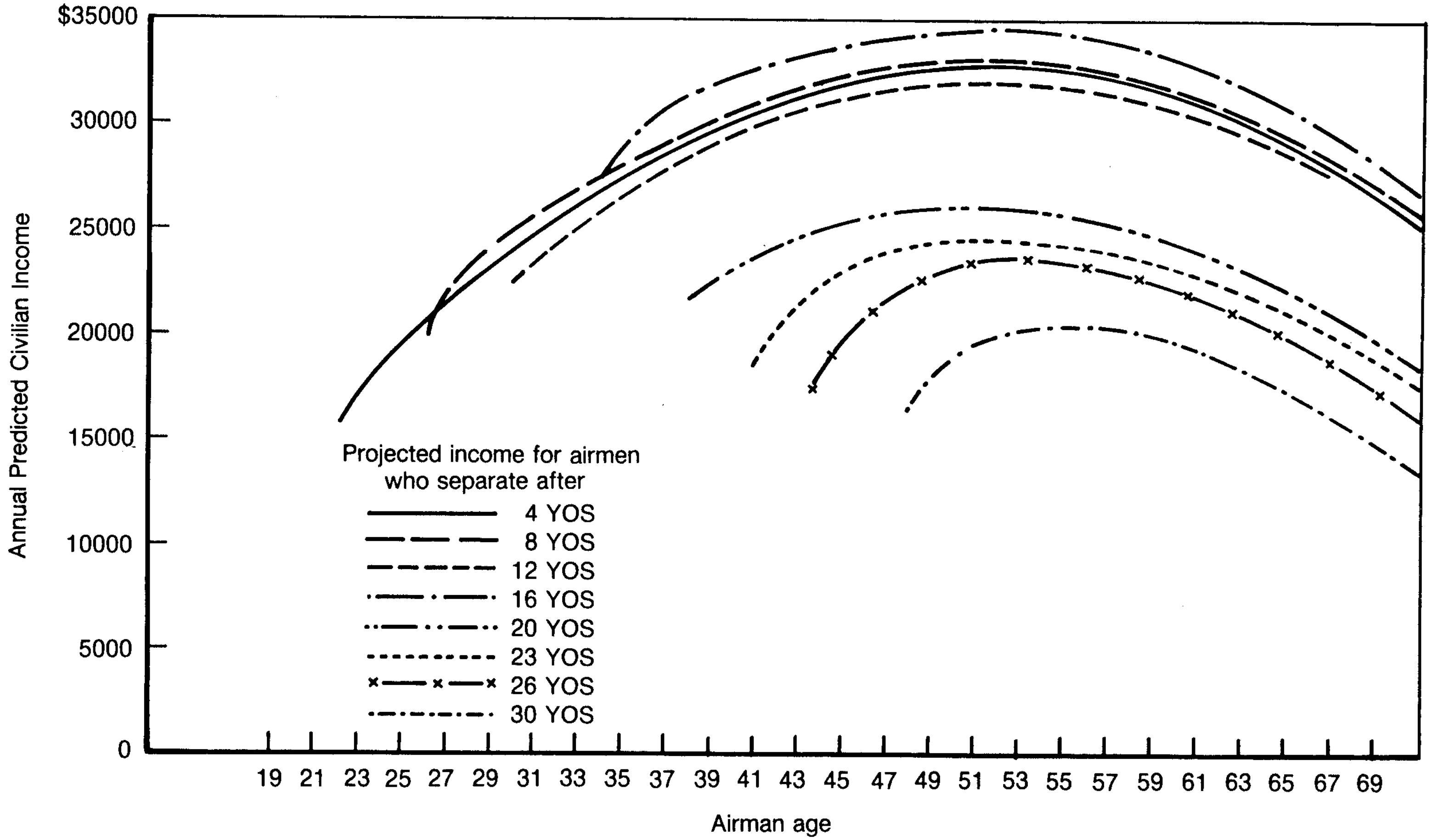
[31]Estimate made from using mean of the education, race, and occupation effects weighted by the number of people in each category.

[32]After an initial adjustment period of a couple of years.

[33]Since disabled and dishonorable discharges are excluded from the Cooper et al. sample.




SOURCE: Cooper, Gunther-Mohr and Lewis, 1984.

Fig. 2 -- Civilian income opportunities by YOS average over occupations

The results of the interpolation to correct for selectivity bias are shown in Fig. 3. These potential civilian earnings streams are used in the simulations. As in the promotion probabilities, the simulation model assumes that 20 percent of an entering cohort face civilian income opportunities that are 10 percent higher than the average, another 20 percent have civilian income opportunities that are 10 percent lower than the average, and the remaining 60 percent have the average civilian income earnings streams. This enables evaluation of the effects of varying civilian income opportunities on retention rates.

In summary, Cooper et al. used the best available data to estimate post-service earnings.[34] Although they did a reasonable job of avoiding many potential biases, they failed to correct for the selectivity bias at each of the decision points. This is likely to be a positive bias of unknown magnitude, and will be most important for the separatees who have served more than one term. However, because the primary goal here is to evaluate the performance of different retention models and simulated data are being used for this purpose,[35] all one needs is plausible civilian income streams. Therefore, Cooper et al. estimates with some ad hoc corrections for selectivity biases are used, especially in those years when the separation rates are low.

### Growth Rates for Military and Civilian Earnings and CPI

Expectations of military personnel about future growth rates for military and civilian income opportunities were assumed to be independent of the current economic environment. In the simulation model, military pay schedule and the CPI are assumed to grow at 4 percent per year. Hence, military pay is assumed to stay constant in real terms. Civilian income opportunities are assumed to grow at 0.5 percentage points higher per year than military pay for the first ten years, and then alternating at -0.5 and +0.5 percentage point

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[34]Actually, they estimated differentials from mean census veteran earnings, but incorporating their differential estimates with estimates of mean wages gives estimates for post-service earnings.

[35]In simulating the data it is assumed that post-service earnings are known with certainity.

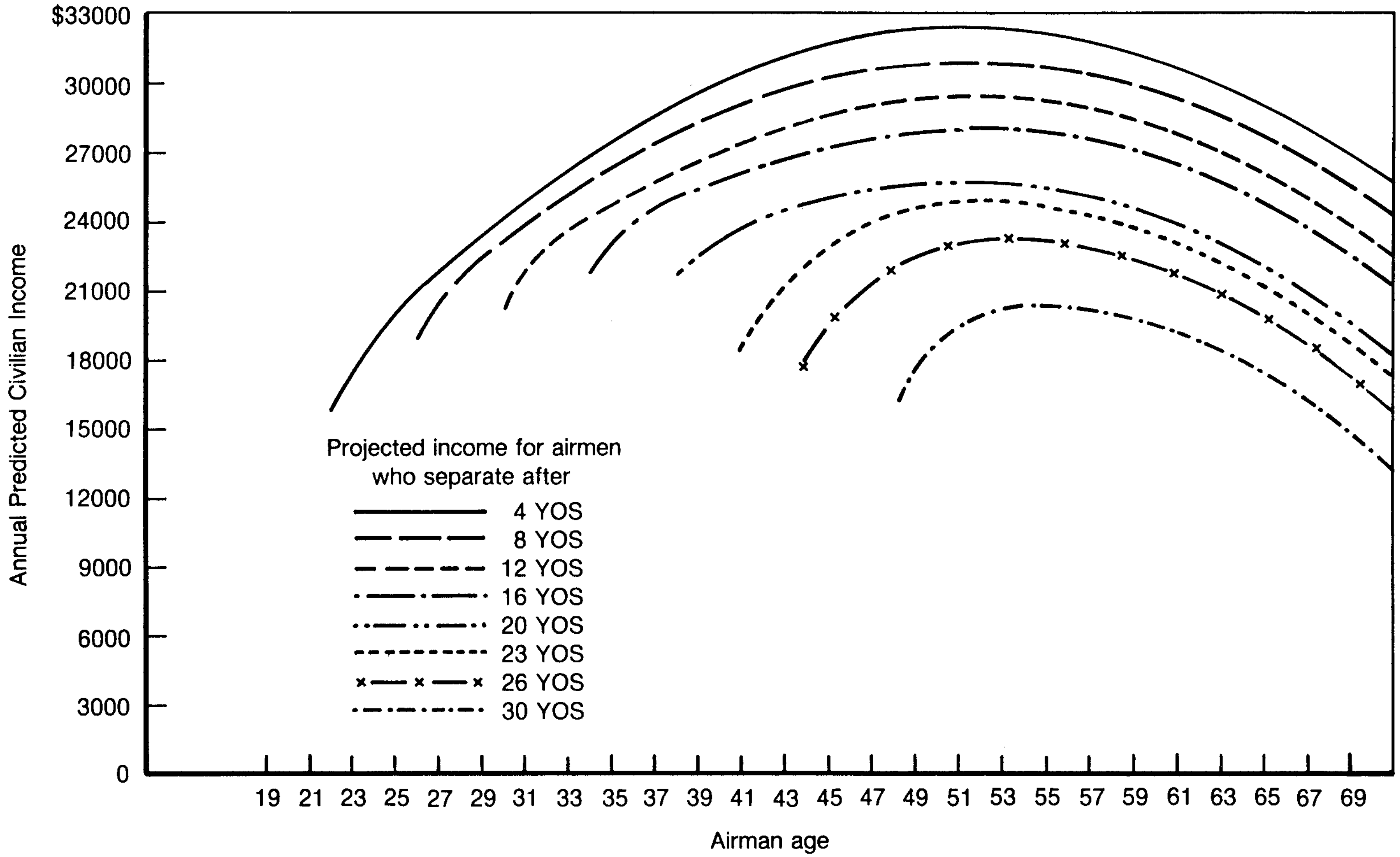


Fig. 3 -- Civilian income opportunities by YOS average over occupations corrected for selectivity bias in 8, 12, 16 YOS

differentials from the growth rates for military pay for the subsequent 20 year periods. Because the civilian to military pay ratio was assumed to be 1.0 in the first period, this ratio ranges from 0.95 to 1.05.

This assumption was originally made to capture the differential effects of military compensation on cohorts that face different civilian economic conditions. But very long computer program execution time for the simulation model prevented analysis of such effects. Nevertheless, the simulation model is set up to run for different fiscal years. Therefore, the effects of pooling cross-sectional time series data on estimation of retention models could be evaluated by running the simulation under different economic conditions for different fiscal years to create data for estimating other retention models.

### Survival Probabilities

The probabilities of living to ages 19 through 103 were obtained from a 1976 table of probabilities and life expectancies by the actuary for the Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs).

### Implicit Discount Rates[36]

An implicit discount rate for an individual is his shadow price for moving resources over time. It is different from the prevailing market interest rate because of such imperfections as the individual's tax rate and the probability of the individual's paying his loans back. Market interest rates in turn are influenced by the collective rate of intertemporal preference of the individuals who make up the markets. However, market interest rates are higher than this rate because of costs of financial intermediation, risks, and inflation. Although intertemporal rate of preference, interest rates, and discount rates are theoretically linked to each other, there are considerable quantitative differences among them. The relevant implicit discount rate in this analysis is a behavioral concept that is totally unrelated to the Office

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[36] I wish to thank my committee member Frank Camm for his suggestions about improving the arguments in this section.

of Management and Budget and DoD requirements to use 10 percent real discount rate for social cost-benefit analyses. It *should be empirically based* and individual responses to changes in deferred compensation should be used to estimate it.[37]

Implicit discount rates permit comparisons of an individual's military and civilian income opportunities. Because the deferred compensation component of the military compensation package is different from most civilian compensation packages, the implicit discount rate of military personnel is an important determinant of their short run stay/leave decisions. Table 6 shows that the present value of a hypothetical $100,000 retirement benefit that will be available at 20 years of service will differ greatly at different years of service and with different discount rate assumptions. Therefore, with alternative discount rate assumptions the importance of potential retirement benefits at the early YOS will vary to a great extent.

With a reduction in the retirement benefits, more losses will be predicted at the early YOS with a low discount rate assumption than with a high discount rate assumption. Because there has not been any major change in the military retirement system, the variation in the military income streams have been due to minor changes in the current

Table 6

PRESENT VALUE OF A FUTURE $100,000 RETIREMENT BENEFIT[a]
(Available at 20 years of service)

| Current YOS | Discount Rate | | | | |
|---|---|---|---|---|---|
| | 0.02 | 0.05 | 0.10 | 0.15 | 0.20 |
| 4 | 72,600 | 44,900 | 20,200 | 9,100 | 4,100 |
| 8 | 78,700 | 54,900 | 30,100 | 16,500 | 9,100 |
| 12 | 85,200 | 67,000 | 44,900 | 30,100 | 20,200 |
| 16 | 92,300 | 81,900 | 67,000 | 54,900 | 44,900 |
| 20 | 100,000 | 100,000 | 100,000 | 100,000 | 100,000 |

[a]Rounded to nearest $100.

[37]This is why it is referred to as an "implicit" discount rate.

compensation component. Lower discount rates will increase the value of future income streams, thereby reducing the relative magnitude of current compensation changes. Hence, the estimated coefficient for the responses of individuals to pay variables will be lower. Therefore, under different discount rate assumptions, the magnitude of the effects of reducing retirement benefits on retention rates at early YOS will not be as large as the changes in the present values of retirement benefits.

Most economists agree that calculating the present values of two income streams by using discount rates is the right way to reduce them to a single number for comparison purposes. But there is much disagreement on the discount rates to be used. The disagreement is not limited to empirical implementation, it also covers the factors to be included in the discount rate. If capital markets were perfect, individuals would save and borrow according to their true time preferences, and the prevailing interest rate (which would be the result of supply and demand forces) would be the appropriate discount rate to use in present value calculations. But there are market imperfections. First, the interest rate for loans exceeds the rate of return earned on savings because of the costs of financial intermediation. If there were no other imperfections, the discount rate would be between the prevailing lending and borrowing rates. However, the discount rate will be lower than the market borrowing rate to the extent individuals itemize their interest payments in their tax forms for deductions. More senior airmen are more likely to itemize deductions (because of learning and higher tax rates), so their discount rates are likely to be lower than those for junior personnel.

Access to consumer loans is limited. Therefore, the discount rate for those who do not have access to loans will be higher than the market borrowing rates. In particular, because access to consumer loans increases with age, the discount rates for younger people may be expected to be higher than those for older people. To the extent that a higher *ex ante* rate reflects only the probability of default and lenders are risk neutral, rising *ex ante* rates with default probability does *not* imply rising *ex post* rates to the borrower. However, if those who remain in the military are more likely to pay their loans back and if the market cannot differentiate between stayers and others in the same age group, then limited access to loans will indeed increase the *ex post* discount rate for personnel who are likely to stay. Income, net worth, and education level may also influence discount rates and should be used in present value calculations for different groups.

Even under certainty of future earnings streams, it is necessary to discount. Some authors suggest that whenever future income streams are uncertain, a risk premium should be added to the risk free discount rate. In particular, it has been suggested that the risk premium should be included in the discount rate only before the retirement date, when eligibility and therefore the value of the annuity is uncertain.[38] However, the uncertainty associated with retirement eligibility is not necessarily an exponential function of time. Although including a risk premium in the discount rate is a step in the right direction, it is not necessarily the best way to deal with uncertainty. Furthermore, even after a person reaches retirement eligibility, the retirement system may be changed. Therefore, that uncertainty should also be dealt with.

Estimation of the appropriate discount rates for different groups of military personnel could best be done by observing their stay/leave decisions under compensation packages that vary in their deferred compensation component. But such data are not available. Therefore, past studies used discount rates that were estimated from responses to military personnel surveys or from civilian databases. In one case, the real discount rate for the Navy enlisted personnel was estimated by using information on lump sum versus annual installment bonuses (Cylke et al., 1982). The applicability of civilian based estimates to military personnel may be limited, and the estimates of discount rates using the bonuses was applicable only to first term enlistees. The estimates of real personal discount rates by the previous studies are given in Table 7.[39] Minimal variability in the deferred compensation component of military income opportunities makes estimation of implicit discount rates by looking at observed behavior very difficult.[40] Therefore, it was decided to evaluate the sensitivity of results to

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[38]Gotz (1985) suggested this idea.

[39]These rates include an irreducible social risk premium.

[40]In a test using ACOL as the behavioral model it was found that differentiation between a discount rate of 2 percent and 11 percent

Table 7

ESTIMATES OF REAL PERSONAL DISCOUNT RATES

| Database | Study | Range of Estimate |
|---|---|---|
| Military personnel surveys | | |
| 1953 Survey | Black, 1983 | Officer : 6.5% - 10.6%<br>Enlisted: 11.0% - 20.2% |
| 1971 Survey | Black, 1983 | Officer : 7.4% - 14.5%<br>Enlisted: 8.2% - 17.5% |
| 1979 Survey | Black, 1983 | Officer : 8.5% - 12.4%<br>Enlisted: 9.8% - 15.0% |
| Bonus payment plans | | |
| Navy, YOS 3,4 | Cylke et al., 1982 | Enlisted: 15.0% - 18.5% |
| Nonprofit institution employees | Gilman, 1976 | Age 18-45: 1.3% - 24.0% |
| Civilian sector employees | Hausman, 1979 | 15.0% - 25.0% |
| | Heckman, 1976 | 18.0% - 20.0% |
| | Landsberger,1971 | 9.0% - 27.0% |

implicit discount rate assumptions, rather than picking a single after-ax discount rate. The simulation model used discount rates of 5 percent, 10 percent, and a tapered discount rate between 20 percent (at YOS 4) and 2 percent (at YOS 30). Tapering was assumed to be exponential in years of service, falling more rapidly at the early YOS. The discount rate used here is a real, risky, *ex post*, after-tax rate for borrowing funds faced by military personnel. The results of sensitivity analyses are reported in Sec. V.

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required a sample size of more than 3000 airmen. Although we have information on more than 3000 airmen, other sources of variation in retention rates would not leave enough room for accurate estimation of discount rates. I wish to thank my committee member William Rogers for his help in developing this test.

## CALIBRATION OF THE SIMULATION MODEL

The simulation model is conceptually based on the DRM. The goal of the calibration process is to find the "best" set of parameter values for the simulation model. "Best" is the set of parameter values that make the model's retention rate predictions most consistent with the observed retention rates in the recent past under the current compensation system.

### Theory

For the sake of simplicity, assume that all airmen have the same promotion probabilities and civilian income opportunities, but differ only in their tastes toward the military. According to the DRM theory, if there were no random shocks, those airmen whose expected value of future income stream in the civilian sector is greater than in the Air Force would leave, and all others would stay.

Define $PVL(j,\gamma,d)$ to be the net return an individual will get by leaving at the decision point j, if his taste toward military life is $\gamma$, and his discount rate is d.[41] Without random shocks, the retention rate at the first decision point would be the proportion of airmen whose $PVL(1,\gamma,d) < 0$.

With random shocks, all airmen whose $\{PVL(1,\gamma,d,\sigma) + x\} > 0$, where x is the value of the random shock an individual receives at the first decision point, would leave and others would stay. The loss probability for an individual can be easily calculated given trial values for the discount rate, d, and the standard deviation of the random shocks, $\sigma$. Another parameter, $\sigma$, is added to the present value calculations because individuals who know of the existence of random shocks will incorporate them into their calculations. Random shocks are assumed to be independent and follow a $N(0,\sigma^2)$ distribution. It is also assumed that individuals know the value of their fixed tastes[42] and that tastes among the population of airmen are normally distributed.

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[41]This is the negative of the present value of cost of leaving.

[42]This assumption may not hold very early in military life. Some researchers also suggest that some people are totally insensitive to economic incentives because they just cannot make it in the military. These two considerations led us to calculate cumulative retention rates as the proportion of airmen who are still in the Air Force at a given YOS from the population of individuals who made it into their third YOS.

Similarly, the loss probability for an individual at the second decision point is the probability of (PVL(2,$\gamma$,d,$\sigma$) + y) > 0), where y is the value of the random shock received at the second decision point. The cumulative probability for an individual of staying past his second decision point will be the product of the probabilities of staying at both the first and the second decision points. Therefore, the cumulative retention rate by the second decision point is

$$\int_{-\infty}^{\infty} \mathrm{Prob}(\mathrm{PVL}(1,\gamma,d,\sigma) + x < 0) \cdot \mathrm{Prob}(\mathrm{PVL}(2,\gamma,d,\sigma) + y < 0) \cdot g(\gamma)d\gamma \qquad (1)$$

where g($\gamma$) is the distribution of tastes, $\gamma$, among the population. The discount rate, d, and variance of random shocks, $\sigma$, are assumed to be known. The retention rate at the second decision point is[43]

$$\frac{\int_{-\infty}^{\infty} \mathrm{Prob}(\mathrm{PVL}(1,\gamma,d,\sigma) + x < 0) \cdot \mathrm{Prob}(\mathrm{PVL}(2,\gamma,d,\sigma) + y < 0) \cdot g(\gamma)d\gamma}{\int_{-\infty}^{\infty} \mathrm{Prob}(\mathrm{PVL}(1,\gamma,d,\sigma) + x < 0) \cdot g(\gamma)d\gamma} \qquad (2)$$

## Data

Actual retention rates were constructed in two different ways: (1) using the median retention rates from the 1977-1981 period,[44] and (2) using retention rates for four cohorts that were followed for two decision points.

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The assumption that individuals know their taste value and that it is a fixed value is more reasonable with the population that makes it to the third YOS. In other words, the attrition in the first two years of service is assumed to be insensitive to economic factors. On average, 80 percent of an entering cohort make it to the third YOS.

[43]This equation corresponds to Eq. (10) in Gotz and McCall (1984), Sec. III.

[44]The data were obtained from a 10 percent sample of the EAGL file described in Walker et al. (1982).

The first method of constructing actual retention rates follows cohorts for four years. That is, the retention rate at the third decision point (say, YOS 12) in 1980 is the proportion of airmen who were in the service in 1976 at YOS 8 and are still present in 1980. The cumulative retention rate by YOS 12 in 1980 is then calculated by multiplying the retention rates at YOS 4, at YOS 8, and YOS 12 in 1980, where retention rates at YOS 4 and YOS 8 are calculated in the same fashion as the retention rate at the third decision point. This procedure was used because we do not have the data to trace each cohort back to their first enlistment point. Furthermore, even if the data were available, they would refer to the period before the draft and that would cause other problems. Originally, the median of the retention rates constructed in this manner was used in the calibration procedure.

This method of constructing retention rates could lead to underestimation of the effects of tastes. The retention rate at the first decision point will be positively correlated with the retention rate at the second decision point, because they are obtained by using the retention rates over the same fiscal years (under the same economic conditions). Actually, everything else being the same, retention rates at consecutive decision points should be negatively correlated, because if more people leave at one decision point the remaining population will have higher tastes for the military.

The second method for constructing retention rates tries to evaluate the extent of the underestimation of the importance of tastes. This is accomplished by following cohorts for two decision points (eight years) instead of one (four years) in constructing the retention rates that are used as the basis for the calibration.[45] The retention rates for the later YOS service are calculated in a similar fashion to the first method, but the cohorts were followed through eight years. That is, the cumulative retention rate at YOS 12 for the cohort of 1970 is

[45]We are actually picking up the cohorts at the end of their first year of service, needing seven more years of data to follow a cohort through its first two decision points. Therefore, we used cohorts who started their military service in 1970 to 1973, because the data cover the period 1971-1981.

obtained by multiplying their cumulative retention rate until YOS 8[46] with the median retention rate between YOS 8 and 12 for the cohorts who were observed both at their eighth and twelfth YOS during 1971-1981.

The calibration procedure is not dependent on the way the retention rates are constructed. After discussing the calibration methodology the parameters obtained by using the two methods of constructing retention rates will be discussed.

## Calibration Methodology

**Step 1: Calculate the PVL for a wide range of taste values.** Figure 4 shows that the PVL for the first decision point decreases smoothly as the taste for the military increases (A denotes low taste and P denotes high taste for the military life). The calibration methodology uses the fact that PVL($j,\gamma,d,\sigma$) decreases smoothly as a function of $\gamma$. That is, using trial values of d and $\sigma$ permits calculation of the PVL for all j and for several widely differing taste values. Then linear interpolation allows obtaining the PVL for other necessary taste values.[47]

**Step 2: Search for the parameters of the taste distribution.** For given values of d and $\sigma$, one can search for the parameters of the taste distribution, $g(\gamma)$, that give the best fit to the historical data.[48] This process can be accomplished fairly easily by evaluating the integral given in Eq. (1) and similar integrals for the other decision points. The goodness of fit measure used is the sum of the squared differences between the model predictions and the historical cumulative retention rates.[49]

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[46]The proportion of the entering cohort remaining in the military past their eighth YOS.

[47]The PVL for the first decision point is a convex function of $\gamma$. Therefore, linear interpolation will slightly underestimate it, thereby giving somewhat higher retention rates than if one were to actually calculate the PVL. This bias is very small (see Table 8). The PVLs at other decision points have similar shapes.

[48]This search can be done by trying many alternative values or by using mathematical optimization techniques.

[49]Cumulative retention rates were used rather than simple retention rates because getting the total number of people present at a certain YOS right is more important than getting the retention rate right. Obviously, with this methodology any other criterion for the objective function can very easily be used to calibrate the model.

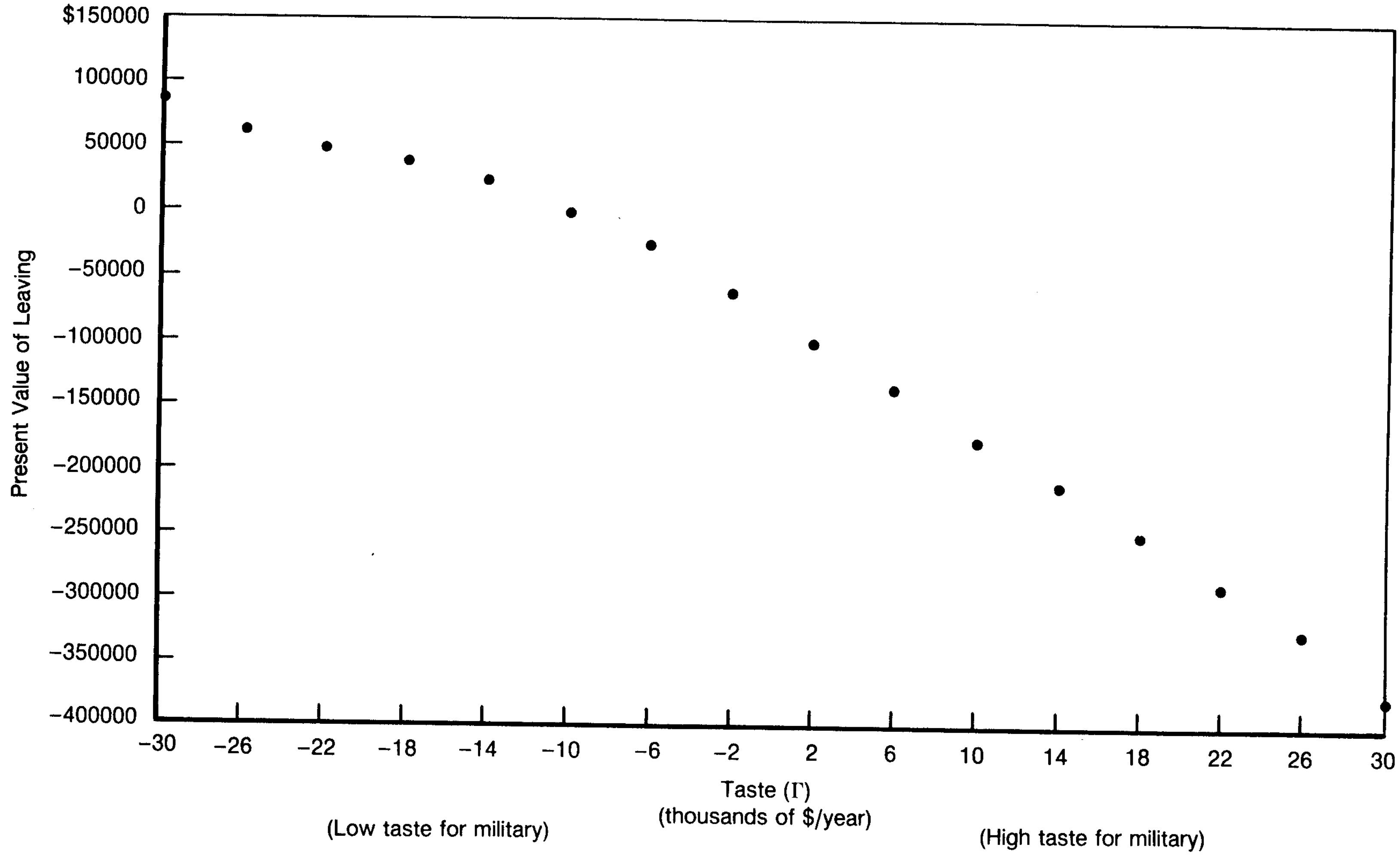


Fig. 4 -- PVL is a smooth function of tastes
(At YOS = 4 for $\sigma$ = 20,000, i = 10%)

**Step 3: Search for the standard deviation of the random shocks distribution.** For a given implicit discount rate, d, this process can be repeated for several values of the standard deviation of the random shocks, σ. Figure 5, which shows the value of the objective function (the sum of the squared differences between the model predictions and the observed retention rates) for different σ, indicates that a quadratic function can effectively approximate the value of the goodness of fit. This holds throughout the range of values of σ of interest. Therefore, after this procedure is repeated for a few values of σ, it is possible to estimate the σ that will minimize the objective function by finding the minimum of the quadratic function that best fits the values already calculated. Finding the parameters of the taste distribution function for this σ is the final stage of the calibration process (i.e., repeat Step 2 for this σ).

**Step 4: Repeat for a set of implicit discount rates.** The same process can be repeated under different assumptions for the implicit discount rate, d. Finding the best discount rate is not attempted, but instead three different calibrations are used under three different implicit discount rate scenarios.

Relaxing the assumption that all airmen have the same promotion probabilities and civilian income opportunities leads to having a family of PVLs, one for each "type" of airman, rather than a single PVL for each decision point.[50] When this assumption is relaxed the methodology discussed will be the same; except in calculating the model's predictions of retention rates the overall retention rate will be the weighted average of the retention rates of each "type" of airman, where the weights are the proportion of the population belonging to each "type."

This methodology is valuable for two reasons: First, it formalizes the search procedure for the parameter values of the model. Therefore, different researchers can repeat it. Second, if ACOL models cannot produce the results obtained by the DRM methodology under certain

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[50]This model has 28 "types" of airmen, where airmen of the same "type" have the same promotion and bonus probabilities, and civilian income opportunities.

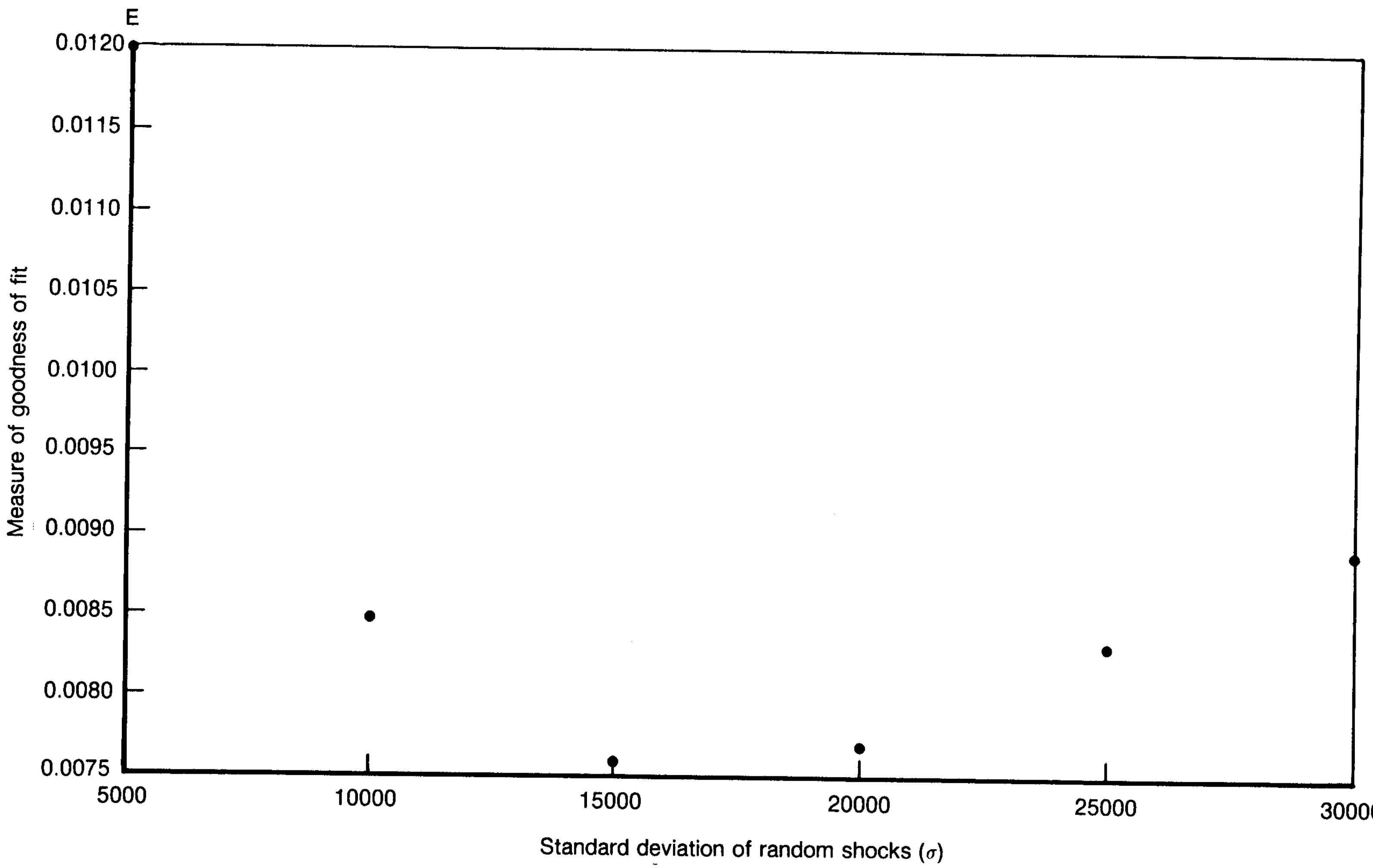


Fig. 5 -- Value of the objective function with respect to the variance of random shocks has a quadratic form

conditions, it may be necessary to estimate the DRM. This methodology provides a formal way of doing so.[51] The results obtained through this procedure are remarkably close to those obtained by actually running the simulation model with the same parameters (see Table 8).[52]

Table 9 compares the retention rates constructed by following four specific cohorts through two decision points with the retention rates obtained through the calibrated simulation model. The variance of the taste distribution, $g(\gamma)$, is larger than the variance estimated by using

Table 8

COMPARISON OF CALIBRATION AND SIMULATION RESULTS:
USING MEDIAN RETENTION RATES AT DIFFERENT YOS

| YOS | Calibration[a] (d=10%) | Simulation[a] (d=10%) | Calibration[b] (d=5%) | Simulation[b] (d=5%) | Median Constructed Retention Rates[c] |
|---|---|---|---|---|---|
| 4 | .378 | .367 | .381 | .373 | .371 |
| 8 | .549 | .537 | .559 | .550 | .528 |
| 12 | .869 | .855 | .836 | .820 | .817 |
| 16 | .987 | .977 | .966 | .955 | .952 |
| 20 | .663 | .660 | .699 | .709 | .530 |

[a] $\sigma = 20000$
$g(\gamma) \sim N(2001, 2500^2)$

[b] $\sigma = 48000$
$g(\gamma) \sim N(401, 900^2)$

[c] These data are constructed according to the first procedure, which follows the cohorts for only 4 years. Behavior of airmen in 1971-1981 was used to construct these rates.

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[51] The methodology described here is similar to that Gotz and McCall used in their estimation of the DRM for officers, but calibration requires fewer data than complete event-histories of airmen, which the formal DRM estimation needs. Only the cumulative retention rates in the period 1971-1981 are used.

[52] Other calibration procedures were unsuccessful in giving similar results with the simulation because of the nonlinearities of the censoring process at each decision point. The simulation mimics the decisionmaking process explicitly, so it is used as the basis for evaluating the appropriateness of the calibration methodology.

the median retention rates (obtained by following cohorts for four years) as shown in Table 8. Therefore, not following the cohorts through at least two decision points does bias the estimates of the taste distribution parameters.[53] This confirms that estimation of the DRM requires longitudinal data that cover several decision points.

The variation in the predicted retention rates by the calibrated model is smaller than the actual variation in the retention rates. There are several possible reasons. The simulation model does not explicitly model the effect of civilian unemployment rates on retention rates, and the unemployment rates varied significantly over this period. Because the cohorts of 1970 and 1971 enlisted before the all volunteer force era, their taste distributions may be different from those of the other cohorts. Finally, some of our assumptions about the expectations of individuals in those cohorts about future military and civilian income opportunities may not be accurate (such as a constant real military income pay schedule). Nevertheless, this exercise shows the difficulty of estimating the parameters of the Dynamic Retention Model.

Recall that we are not formally estimating the parameters of the DRM, only finding plausible parameters through the calibration procedure to use in the simulations. During simulation these parameters are assumed to be true and the individuals actually behave according to them. These parameters and the assumptions about the economic climate that were described in the previous sections lead to retention rates that are in fact typical of the observed retention rates. Also, the elasticity of first term retention rates to a uniform change in the military pay schedule is between 2 and 3, which is in accord with previous studies. Table 10 gives the base case retention rates that were obtained through the simulation model under the current compensation system. About 90 percent of the force has fewer than 20 YOS. Therefore, predictive accuracy in those years is important. The

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[53]Longitudinal data covering a larger horizon are likely to improve the estimates of the parameters of the DRM, but the retention rates after YOS 8 until YOS 20 are very high so the biases that may be caused by following the cohorts through only two decision points are likely to be small.

Table 9

COMPARISON OF SIMULATION AND ACTUAL RETENTION RATES
FOR FOUR COHORTS

| Cohorts | YOS | Simulation[a] (d=10%) | Simulation[b] (d=5%) | Simulation[c] (d=20-2%) | Actual[d] |
|---|---|---|---|---|---|
| 1970 | | | | | |
| | 4 | .394 | .394 | .405 | .307 |
| | 8 | .541 | .531 | .531 | .567 |
| | 12 | .831 | .871 | .958 | .833 |
| | 16 | .955 | .978 | .995 | .952 |
| | 20 | .704 | .674 | .712 | .580 |
| 1971 | | | | | |
| | 4 | .383 | .384 | .391 | .324 |
| | 8 | .564 | .550 | .555 | .596 |
| | 12 | .829 | .867 | .954 | .829 |
| | 16 | .950 | .978 | .995 | .950 |
| | 20 | .700 | .676 | .714 | .579 |
| 1972 | | | | | |
| | 4 | .382 | .386 | .391 | .393 |
| | 8 | .589 | .570 | .586 | .585 |
| | 12 | .822 | .864 | .952 | .830 |
| | 16 | .951 | .979 | .995 | .953 |
| | 20 | .699 | .677 | .710 | .571 |
| 1973 | | | | | |
| | 4 | .386 | .391 | .396 | .463 |
| | 8 | .598 | .578 | .598 | .540 |
| | 12 | .814 | .858 | .949 | .828 |
| | 16 | .952 | .984 | .996 | .952 |
| | 20 | .704 | .681 | .719 | .574 |

[a] $\sigma = 30000$
$g(\gamma) \sim N(0,5001^2)$

[b] $\sigma = 40000$
$g(\gamma) \sim N(500,2001^2)$

[c] $\sigma = 26000$
$g(\gamma) \sim N(1000,2001^2)$

[d] These rates are obtained by following the cohorts through two decision points.

remainder of this report will compare the effects of alternative retirement systems with these base case retention rates. It will also evaluate the ACOL types of retention models according to their estimation of these rates and their predictions for alternative retirement systems.

## SUMMARY

The DRM is the model most concerned with capturing the behavioral structure of retention behavior. The importance of this could best be explained through an example.[54] Consider data on the trajectory of a ball that in repeated trials rolls down an inclined plane resting on a table of known height. Assume that the characteristics of the surface and the ball are known. It is also known that the ball is initially placed on different points on the plane with zero initial speed, but the

Table 10

BASE CASE RETENTION RATES
(Simulation model under the current compensation system)

| YOS | Simulation[a] (d=10%) | Simulation[b] (d=5%) | Simulation[c] (d=20-2%) |
|---|---|---|---|
| 4 | .327 | .326 | .338 |
| 8 | .539 | .535 | .543 |
| 12 | .809 | .853 | .941 |
| 16 | .951 | .971 | .998 |
| 20 | .726 | .705 | .725 |
| 21 | .847 | .814 | .877 |
| 22 | .813 | .785 | .851 |
| 23 | .772 | .742 | .813 |
| 24 | .818 | .771 | .852 |
| 25 | .788 | .763 | .858 |
| 26 | .547 | .506 | .466 |
| 27 | .686 | .622 | .608 |
| 28 | .519 | .473 | .481 |
| 29 | .536 | .478 | .499 |

a $\sigma = 30000$
$g(\gamma) \sim N(0,5001^2)$

b $\sigma = 40000$
$g(\gamma) \sim N(500,2001^2)$

c $\sigma = 26000$
$g(\gamma) \sim N(1000,2001^2)$

[54] This example was originally developed by Rand colleague Steven Salant.

inclination of the plane to the table is not known. The analyst is asked to observe data on the initial placement of the ball and where the ball makes contact with the floor and to predict what will happen under a new policy environment where the ball will be placed at a point on the plane but at the same time the angle of the plane to the table will be increased by a specified amount. If the slope of the plane is not changed, a statistician with no knowledge of physics could estimate where the ball would fall the next time the ball is dropped by correlating the location of the placement of the ball with the observed contact points on the floor. However, when the angle of the plane is changed he will be at a loss! But if the statistician knew about physics, he would probably try to estimate the angle of the plane to the table. In that case he would be able to make good predictions when the angle of the plane is changed.

Although our knowledge of human behavior may not be as solid as our knowledge of physics, by attempting to get the behavioral model right (attempting to use knowledge of physics) the DRM tries to estimate the underlying parameters (the angle of the plane) rather than using correlations between cost-of-leaving measures and retention rates (correlating the starting point of the ball with the point of contact on the floor). At least in theory, the DRM (statistician *with* knowledge of physics) could make better predictions than other models that do not capture the behavioral factors fully (statistician *without* knowledge of physics). This is similar, in spirit, to the "rational expectations" revolution in macroeconomics, which emphasizes the theoretical structure of the models and points out that models based on structures that are likely to be changed by the policy intervention cannot be used in policy analysis.

Especially in analyzing policies that are structurally different from past policies (such as retirement), more emphasis has to be placed on getting the theoretical structure of the model right. However, in practice, empirical implementation of the theoretically more rigorous model, the DRM, is difficult. Therefore, a "theoretically correct" model, the DRM, is used to generate pseudo-data, which in turn can be used to evaluate the simpler models. Short of running an experiment by changing the retirement system and observing behavioral effects, this methodology is the only way it is possible to evaluate the performance of the simpler models in predicting structurally different policies. The inputs are as important as the underlying theory. That is, the "what you put in is what you get out" concept works very strongly. Therefore, special attention was paid to the preparation of inputs and the calibration of the simulation model to mimic the observed retention rates in the period 1971-1981.

# IV. QUANTIFICATION OF THE LIMITATIONS OF RETENTION MODELS

The previous sections showed that the predictions of the various retention models will be biased and described a methodology to quantify these biases. The magnitude of the biases changes with the retirement policy that is studied. Eight alternative retirement policies are examined in this section, and potential improvements of the ACOL model to reduce its biases are described. Major emphasis is placed on the ACOL model for two reasons. First, it is the most commonly used model in analyzing retirement policies. For example, QRMC V, which conducted an extensive study of the military retirement system, used the ACOL model. Second, there is already evidence that the biases in other models are frequently quite large. Warner (1981) found that the PVCOL model predicts a 50 to 60 percent increase in the first term retention rate because of a 10 percent increase in the military pay schedule and concluded that this was wholly unreasonable. The end of the section is briefly devoted to the PVCOL and PPM models.

The limitations of the models are quantified using the following process: (1) Airmen decisions are simulated under the current compensation system, (2) various retention models are estimated using the data created from the simulations, (3) the estimated retention models are used to predict the effects of alternative retirement systems on retention rates, (4) airmen decisions are simulated under the same alternative retirement systems, and (5) the predictions of the retention models are compared with the simulated responses under new policies. The basis for the simulations is the theoretically most rigorous and complete model, the DRM.[1] The results in this section are based on the assumption that the simulations represent the real world. The retention rates obtained by the simulations under the current retirement system

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[1]If desired, a more complex decisionmaking process can also be used as the basis for the simulations.

mimic the actual retention rates between 1971 and 1981. Furthermore, the simulation model gives logically consistent results for changes in the retirement system. However, just as one cannot fully test military capability without going to war, one cannot fully test the retention models without actually changing the retirement system. But just as war games can give an idea about military capability, a simulation methodology permits quantification of the ACOL model's limitations. As discussed earlier, one of the major difficulties is the estimation of the implicit discount rate. To be able to deal with this difficulty, three different simulations with three different discount rate assumptions were used: (1) a 10 percent real discount rate, (2) a 5 percent real discount rate, and (3) a tapered discount rate exponentially declining from 20 percent at YOS 4 to 2 percent at YOS 30.

## RETIREMENT POLICIES ANALYZED

Analysis of the retirement policies had *two goals*: first, to be able to analyze the effects of *changes in different components* of the retirement system such as the multiplier, eligibility point, cost of living adjustments (COLA), base pay, and the timing of payments; and second, to be able to cover a *wide range of potential proposals*. Therefore, many policies analyzed are hypothetical; but some are currently being considered, and in one case an already implemented policy is analyzed that is using the average of the three highest years' base pay in the benefits calculations.[2]

Eight policies were analyzed to cover the range of policies that have been (see Appendix D) or currently are being considered. Although all of these policies will be briefly described to indicate their range, this section will examine three of them: a penalty on the multiplier for early retirees (Policy 2), less than full COLA protection (Policy 4), and delayed eligibility for retirement (Policy 6). The three illustrate the results obtained from the analysis of all the others.

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[2]These models will be transferred to the Air Force to be used in analyzing other proposals.

### Policy 1 (Current)

In the current retirement system personnel who retire after 20 or more YOS (the retirement eligibility) receive a lifetime annuity equal to the multiplier (2.5 percentage points for each YOS) times the final basic pay[3] multiplied by YOS. The annuity is inflation protected.[4]

### Policy 2 (1 Percent Permanent Penalty on Multiplier)

In the second policy, the multiplier is equal to 2.0 percentage points for the first 20 YOS and 3.5 percentage points for each year between YOS 20 and 30. Equivalently, the multiplier is 2.5 percentage points for each YOS minus 1.0 percentage point for each year before YOS 30. Otherwise, the policy is the same as the current policy. For example, an individual who retires at YOS 20 gets 40 percent of his basic pay as the retirement annuity; one who retires at YOS 25 gets 57.5 percent of the basic pay; and one who stays until YOS 30 gets 75 percent of his final basic pay. This policy penalizes the early retirees when compared with the current policy.

### Policy 3 (1 Percent Temporary Penalty on Multiplier)

In the third policy, the multiplier is the same as in the second policy until 30 years after the first enlistment point. Then it becomes the same as the current multiplier, 2.5 percentage points per YOS served. That is, those who retire before serving for 30 years get penalized for the number of years left until YOS 30. For example, an individual who retires at YOS 20 gets 40 percent of his basic pay as the retirement annuity for the first 10 years of his retirement and then he starts getting 50 percent of his final basic pay (fully inflation protected) for the rest of his life.

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[3]For all retirees whose date of entrance into military service is after September 7, 1980, the retirement pay will be based on the average basic pay in the three highest years. (See Policy 8.)

[4]The Congress placed a three-year limitation on CPI adjustments for FY83-FY85 for retirees under age 62.

### Policy 4 (COLA = CPI - 1%)

The fourth policy restricts the COLA adjustments at 1 percentage point below the increases in the consumer price index (CPI).[5] The remaining components of the retirement system are the same as in the current policy. This policy influences both the early retirees and those who retire after 30 YOS.

### Policy 5 (Flat Multiplier × YOS = 50%)

In the fifth policy, the percentage of final basic pay paid as the retirement benefits remains constant at 50 percent over years of service. That is, individuals who retire after 20 YOS and those who retire after 30 YOS will both get 50 percent of their final basic pay as the retirement annuity. However, their annuities will be different because the basic pay changes between YOS 20 and 30. Unlike the second and third policies, this policy penalizes those who stay more than 20 YOS compared with the current policy.

### Policy 6 (Eligibility at YOS 23)

In the sixth policy, individuals cannot receive retirement benefits if they leave before serving 23 years. All other aspects of the retirement system are the same as in the current policy. For example, an individual who retires at YOS 23 will get 57.5 percent of his final basic pay as the retirement annuity.

### Policy 7 (Payments Delayed Until YOS 30)

In the seventh policy, individuals start getting paid their retirement annuities only after their 30th anniversary with the military. That is, an individual who retires at YOS 20 will not be paid any annuity for the first ten years after retirement, then he will start receiving 50 percent of his final basic pay (fully inflation protected) for the rest of his life.

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[5]The CPI was assumed to increase at 4 percent per year. Therefore, military retirement annuities increase at 3 percent per year.

### Policy 8 (High-three Basic Pay)

In the eighth policy, the basic pay that is used in calculating the retirement benefits is based on the average of the basic pays in the three highest years. This policy already applies to those who entered the military after September 7, 1980.

### Policy 9 (COLA and Multiplier Penalty)

The ninth policy has two changes to the current system. First, the multiplier for the first 20 YOS is 2.25 percentage points per YOS and then it increases 3.0 percentage points for each year between YOS 20 and 30. Second, the COLA is restricted at 1 percentage point less than the increases in CPI until age 62, then full COLA protection is provided.

## LIMITATIONS OF THE ACOL MODEL

There are many ACOL models. They differ mainly in the proxy used for censoring of tastes, changing the mean of the taste distribution in a cohort with YOS. Most applications use a function of YOS as the proxy for censoring of tastes. These functions include dummy variables indicating each decision point and natural logarithm of years of service. QRMC V used only one dummy variable indicating YOS less than or equal to five. Different versions of the ACOL model will have different biases. This study uses QRMC V's version as the base case ACOL model in evaluating the limitations of the ACOL methodology.

### ACOL Estimates

The ACOL model was estimated with the data created by three simulations under the current retirement system, one under each discount rate assumption. Tables 11, 12, and 13 show the estimated coefficients, which in all three cases are similar. But the coefficient of the ACOL variable is larger in Table 11 when compared with Tables 12 and 13. The differences in the ACOL coefficients are consistent with previous findings. When the dispersion in tastes is greater (when individuals are less sensitive to pay), the coefficient of the ACOL variable is greater (implying *higher* sensitivity to pay). Gotz and McCall (1984) estimated the ACOL model for Air Force officers using the same data as

Table 11

PARAMETER ESTIMATES OF ACOL (QRMC V)[a] FROM SIMULATED DATA[b], DISCOUNT RATE 10 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 1.095 | 0.0061 |
| ACOL[c] | 0.101 | 0.0017 |
| YOS = 4 | -1.376 | 0.0090 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979, and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(0,5001^2)$ and they make up to 14 Stay/Leave decisions during their military career.

[c]Expressed in $ thousands.

those in their estimates of the DRM and found the same phenomenon, which is due to the omitted variable (taste) bias discussed in Sec. II. Because average value of tastes, the annualized cost of leaving measure, and the retention rates increase with YOS, the retention effects of pay will be overstated. Furthermore, the predicted retention rates by the ACOL model should be larger than the actual retention rates in the earlier YOS and smaller in the later YOS. The large, significant negative coefficient for the YOS=4 dummy variable and the comparison of the predicted and actual (simulated) retention rates in Table 14 confirm that the censoring of tastes is not fully captured in the QRMC V ACOL.

In previous work, the evaluation of the limitations of ACOL methodology was limited to what has been discussed until this point. These findings are in agreement with earlier work. However, in a simulation world the standard deviation of the taste distribution is

Table 12

PARAMETER ESTIMATES OF ACOL (QRMC V)[a] FROM SIMULATED DATA[b], DISCOUNT RATE 5 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
| --- | --- | --- |
| Intercept | 0.916 | 0.0062 |
| ACOL[c] | 0.085 | 0.0010 |
| YOS = 4 | -1.063 | 0.0097 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979, and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(500,2001^2)$ and they make up to 14 Stay/Leave decisions during their military career.

[c]Expressed in $ thousands.

known. Therefore, ACOL's estimate of the standard deviation of the taste distribution may be compared with the actual standard deviation. Recall that ACOL's estimate for the standard deviation of tastes is the inverse of the coefficient of the ACOL variable (see Sec. II). Table 15 compares ACOL estimates with the actual taste distribution standard deviations. Two observations can be made from Table 15. First, the higher the actual standard deviation of tastes, the lower is ACOL's estimate. Second, the ACOL's estimate is much larger than the actual standard deviations. As discussed in Sec. II, this is because the existence of random shocks was ignored. Basically, ACOL's estimate of the variance of tastes incorporates some of the variance of the random shocks.[6] The implication of this bias is that ACOL will underpredict the effects of changes in the retirement system on retention rates.

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[6]The actual interaction is more complicated than this. See Sec. II for more detail.

Table 13

PARAMETER ESTIMATES OF ACOL (QRMC V)[a]
FROM SIMULATED DATA,[b]
DISCOUNT RATE TAPERED FROM 20% to 2%

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 0.966 | 0.0067 |
| ACOLc | 0.076 | 0.0008 |
| YOS = 4 | -1.257 | 0.0093 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979, and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(1000,2001^2)$ and they make up to 14 Stay/Leave decisions during their military career.

[c]Expressed in $ thousands.

## Importance of ACOL's Limitations

This subsection attempts to quantify the net effect of the biases discussed above. Because ACOL does not predict the actual retention rates, users of ACOL usually adjust ACOL predictions.[7] Therefore, we took a similar approach in obtaining adjusted predictions from the ACOL model, which were obtained in the following manner: (1) ACOL was estimated using the simulated data under the current retirement system, (2) the residuals of the ACOL model under the current retirement system were used to determine the adjustment factors, (3) ACOL values for a new retirement policy were calculated, (4) new retention rates were obtained

[7]Personal communication with Lt. Col. Sal Monaco when he was the division chief of AF/MPXE.

Table 14

COMPARISON OF SIMULATED RETENTION RATES
WITH ACOL (QRMC V) PREDICTIONS

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Simulated retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL prediction | .326 | .723 | .740 | .820 | .664 | .376 | .288 | .180 |
| 5% | | | | | | | | |
| Simulated retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL prediction | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| 20%-2% | | | | | | | | |
| Simulated retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL prediction | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |

by substituting the new ACOL value in the estimated equation, and (5) the new retention rates were adjusted by using the factors obtained in step 2.[8]

Table 15

COMPARISON OF THE ACTUAL STANDARD DEVIATION OF TASTES WITH ACOL (QRMC V) ESTIMATES

| Discount Rate | Actual Standard Deviation of Tastes | ACOL's Estimate |
|---|---|---|
| 10%[a] | 5001 | 9900 |
| 5%[b] | 2001 | 11700 |
| 20%-2%[c] | 2001 | 13200 |

[a]Tastes are distributed according to N(0,5001²), random shocks are distributed according to N(0,30000²).

[b]Tastes are distributed according to N(500,2001²), random shocks are distributed according to N(0,40000²).

[c]Tastes are distributed according to N(1000,2001²), random shocks are distributed according to N(0,26000²).

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[8]The adjustment factor was obtained by finding the necessary value to be added to ($\beta_0 + \beta_1 \cdot$ (YOS=4) + $\beta_2 \cdot$ ACOL) before exponentiating the value in parentheses to reduce the residual of a YOS "type" of airmen cell to zero, where different "types" of airmen have different financial opportunities. This adjustment factor was then added to ($\beta_0 + \beta_1 \cdot$ (YOS=4) + $\beta_2 \cdot$ ACOLnew) before exponentiating the value in parentheses. Because the effect of the ACOL variable is dependent on the retention rate through $(r_i \cdot (1 - r_i)) \cdot \beta_2$, this adjustment will reduce the effect of ACOLnew when the original retention rate was greater than .5 and closer to 1.0 than the original ACOL prediction. Another adjustment method could be to add the original residual to the predicted new retention rate under the new policy. But then adjusted retention rates that are greater than 1.0 or smaller than 0.0 could be obtained. Nevertheless, the adjustment method does not materially alter the results. See Appendix B for an example of the differences among different adjustment methods.

Table 16 shows the differences between the simulated effects of a retirement policy change and ACOL predictions of those effects. The first row gives the retention rates under the current retirement policy. The second row is ACOL's predictions under current policy. These rows are repetitions of the information on Table 14; they are provided for reference purposes. The third row is the adjusted ACOL prediction under the current policy. The fourth row is the difference in simulated retention rates between the current policy and the new policy. In this case it is Policy 2, 1 percent permanent penalty on the multiplier for early retirement. The fifth row is the predicted retention rate by the ACOL model, and the sixth row shows the proportion of the simulated change that was picked up by the ACOL model. The next four rows translate the effects of retention rates to the number of airmen present in the beginning of a term, where the entry cohort size is assumed to be 80,000. The final four rows translate the effects of retention rates on total number of manyears served in a term.[9] Looking at the available number of airmen and man-year figures is informative because the retention rates per se do not show the lasting effect of losses in the early years of service.

Table 16 shows that the ACOL model grossly underestimates the retention effects of reducing retirement benefits for early retirees implying that the biases caused by ignoring random shocks are larger than the biases caused by inadequate handling of the censoring of tastes. The underestimation is most serious at the end of second and third terms, at YOS 8 and 12, where most individuals make a career decision to stay or leave the military. These are the decision points where the largest number of airmen are influenced.

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[9]Because in this model individuals make decisions only at the end of the terms and at each year after YOS 20, the losses were distributed during the term according to fixed proportions determined from the experience in the past 10 years. Although this assumption is not entirely correct, for the purpose of translating the effects of retention rates to manyears it is a reasonable approximation. In the first four years, 65 percent of the losses are assumed to occur at the end of the term; in the second term this percentage increases to 70 percent; and then in the following three terms it increases to 75 percent, 80 percent, and 95 percent, respectively. The remaining losses occur at the midpoint of the term. In the retirement years the losses occur at the midpoint of the year.

Table 16

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 10 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .327 | .539 | .809 | .951 | .726 | .532 | .353 | .191 |
| ACOL estimate | .327 | .724 | .741 | .821 | .664 | .376 | .288 | .181 |
| ACOL estimate (adjusted) | .327 | .539 | .809 | .951 | .726 | .532 | .352 | .189 |
| Simulated Effect | -.003 | -.016 | -.024 | -.015 | .062 | .072 | .044 | .028 |
| Predicted Effect (ACOL) | -.001 | -.003 | -.008 | -.009 | .022 | .036 | .027 | .034 |
| Predicted/Simulated | .444 | .189 | .330 | .578 | .364 | .504 | .616 | 1.194 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -109 | -136 | -217 | -304 | 19 | 297 | 227 |
| Predicted/simulated | 1 | .443 | .255 | .290 | .348 | -1.727 | .530 | .558 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -76 | -453 | -588 | -907 | -1188 | 523 | 964 | 532 |
| Prediction/simulated | .444 | .390 | .261 | .296 | .348 | .486 | .565 | .659 |

[a]95 percent of the airmen who start the term that covers YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in the YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period that covers YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period that ends at the YOS indicated by the column.

In Table 17, the effects of reducing the COLA protection, Policy 4, are described. Here, too, the ACOL model underestimates the retention effects of reducing COLA protection. Furthermore, in the retirement years the ACOL predictions are not even in the right direction simply because of inadequate modeling of the censoring of tastes. When many more airmen leave under the new policy compared with the current policy, the remaining airmen will, on the average, have higher tastes for the military than under the current policy. Therefore, they will be more likely to stay. But because the ACOL model is estimated under the current policy and there is no variable in the model to trace the effects of extra losses in the earlier years to the retention rates in the later YOS, it overpredicts the losses in the later YOS.

The analysis of other retirement policies described in the beginning of this section repeats similar pictures. For example, Table 18 shows the effects of delaying the retirement eligibility to YOS 23. Although the ACOL model predicts the retention effects at YOS 16 and 20 reasonably well, it fails to predict the magnitude of the effects in the earlier YOS.

Tables 16, 17, and 18 were based on simulations with the 10 percent discount rate assumption. Table 19 shows that under a 5 percent discount rate assumption, both the simulated responses and ACOL's predictions of the effects of Policy 2 (a 1 percent permanent penalty on the multiplier for early retirement) are larger. However, the extent of the biases in the ACOL predictions do not change materially. It still underpredicts retention effects, especially at the early YOS. Appendix B shows the analyses of the same policies under different discount rate assumptions.

## Potential Improvements to ACOL

The first limitation of the ACOL model was inadequate handling of the censoring of tastes. One way to deal with this limitation would be to borrow the concept of taste proxy from the PPM model and use the continuation probability until the current decision point. However, less than 10 percent of an entering cohort remains in the military in the retirement years, so the continuation rates in those years are very

Table 17

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 4, DISCOUNT RATE 10 PERCENT (COLA = CPI - 1%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .327 | .539 | .809 | .951 | .727 | .532 | .353 | .191 |
| ACOL estimate | .327 | .724 | .741 | .821 | .664 | .376 | .288 | .181 |
| ACOL estimate (adjusted) | .327 | .539 | .809 | .951 | .727 | .532 | .352 | .189 |
| Simulated effect | -.004 | -.020 | -.030 | -.019 | .011 | .015 | .018 | .031 |
| Predicted effect (ACOL) | -.001 | -.003 | -.006 | -.007 | -.004 | -.008 | -.010 | .025 |
| Predicted/simulated | .354 | .154 | .208 | .351 | -.356 | -.511 | -.578 | .814 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -326 | -701 | -968 | -1119 | -704 | -264 | -21 |
| Predicted effect (ACOL) | 0 | -112 | -143 | -202 | -267 | -237 | -184 | -105 |
| Predicted/simulated | 1 | .347 | .204 | .210 | .240 | .337 | .697 | 5 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -228 | -1530 | -2941 | -3933 | -4435 | -1421 | -467 | 61 |
| Predicted effect (ACOL) | -80 | -470 | -602 | -837 | -1069 | -836 | -588 | -94 |
| Prediction/simulated | .354 | .307 | .205 | .213 | .241 | .589 | 1.258 | -1.541 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in the YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period that covers YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 18

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 6, DISCOUNT RATE 10 PERCENT
(Retirement eligibility at YOS 23)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .327 | .539 | .809 | .951 | .727 | .532 | .353 | .191 |
| ACOL estimate | .327 | .724 | .741 | .821 | .664 | .376 | .288 | .181 |
| ACOL estimate (adjusted) | .327 | .539 | .809 | .951 | .727 | .532 | .352 | .189 |
| Simulated effect | -.005 | -.024 | -.036 | -.032 | .233 | .158 | -.022 | -.006 |
| Predicted effect (ACOL) | -.001 | -.002 | -.012 | -.026 | .186 | .230 | 1E-04 | 3E-04 |
| Predicted/simulated | .231 | .096 | .332 | .809 | .800 | 1.456 | -.005 | -.057 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -396 | -827 | -1152 | -1421 | 1162 | 2046 | 587 |
| Predicted effect (ACOL) | 0 | -91 | -108 | -256 | -530 | 1535 | 2982 | 1050 |
| Predicted/simulated | 1 | .231 | .131 | .223 | .373 | 1.321 | 1.457 | 1.789 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -277 | -1845 | -3474 | -4717 | -5427 | 7528 | 4152 | 897 |
| Predicted effect (ACOL) | -63 | -376 | -508 | -1135 | -1915 | 8748 | 6376 | 1713 |
| Prediction/simulated | .231 | .204 | .147 | .241 | .353 | 1.162 | 1.536 | 1.909 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in the YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period that ends at the YOS indicated by the column.

Table 19

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED
EFFECTS OF POLICY 2, DISCOUNT RATE 5 PERCENT
1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| ACOL estimate | .326 | .668 | .732 | .863 | .661 | .374 | .280 | .150 |
| ACOL estimate (adjusted) | .326 | .535 | .853 | .971 | .705 | .474 | .296 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .049 | .027 |
| Predicted effect (ACOL) | -.005 | -.014 | -.016 | -.010 | .024 | .043 | .036 | .039 |
| Predicted/simulated | .360 | .272 | .360 | .604 | .339 | .477 | .734 | 1.443 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -413 | -584 | -712 | -808 | -310 | 191 | 201 |
| Predicted/simulated | 1 | .360 | .306 | .329 | .356 | .330 | .941 | .779 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -289 | -1758 | -2403 | -2886 | -3183 | -189 | 752 | 467 |
| Prediction/simulated | .360 | .348 | .309 | .331 | .356 | .232 | .798 | .836 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

close to each other. Another variable that could be used as the taste proxy can be obtained from a transformation of the continuation rate variable. For example, given a continuation probability, the increase in the mean of the truncated taste distribution from the mean of the untruncated distribution can be calculated (see Appendix B for the calculation of the truncated mean of normal probability distribution). Therefore, the truncated mean for N(0,1) can be used as a taste proxy. Both taste proxies have been used to improve the ACOL model, and the truncated mean variable worked slightly better than the continuation rates. This taste proxy, its square, and interactions were used with the ACOL variable as an improvement to the ACOL (QRMC V) model. The coefficient estimates of this model are presented in Appendix B. Tables 20, 21, 22, and 23, which show the performance of this model in analyzing different retirement systems, are comparable to Tables 16-19.

In all cases this improved ACOL outperforms QRMC V ACOL, in that it can predict a larger proportion of the simulated retention effect. Because the effects of random shock are also dependent on the censoring of tastes, the truncated mean variables are capturing some of that effect as well. One additional advantage of this variable is that it serves as a self-correcting factor. That is, if the retention rate at a particular YOS is predicted to be reduced more than it actually would, then at the next decision point the retention rate will be biased upward, other things equal. That is because if more people are predicted to leave, at the next decision point the average tastes, and therefore retention rates, will be predicted to be higher. Hence with the improvement, the ACOL model predicts the effects on number of manyears considerably better. It may miss the timing of some of the losses, but the total effect is more accurate. However, this improvement is by no means a panacea for all of ACOL's limitations.

Another way to deal with the effect of random shocks is to estimate a model with YOS dummy variables for each decision point. By not restricting the YOS variable to follow a specific path, such as log(YOS), the complex nature of the interaction between the censoring and random shocks could be captured by the YOS dummy variables. However, in this specification the estimated censoring effects will be

Table 20

COMPARISON OF ACOL (TRNMN) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 10 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .327 | .539 | .809 | .951 | .727 | .532 | .353 | .191 |
| ACOL estimate | .323 | .622 | .765 | .878 | .689 | .476 | .357 | .367 |
| ACOL estimate (adjusted) | .327 | .539 | .809 | .951 | .727 | .532 | .352 | .189 |
| Simulated effect | -.003 | -.016 | -.023 | -.015 | .063 | .072 | .044 | .028 |
| Predicted effect (ACOL) | -.007 | -.004 | -.015 | -.017 | .038 | .020 | .006 | .028 |
| Predicted/simulated | 2.244 | .244 | .629 | 1.114 | .608 | .280 | .135 | .981 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -553 | -395 | -523 | -680 | -105 | 100 | 63 |
| Predicted/simulated | 1 | 2.244 | .737 | .696 | .777 | 9.545 | .179 | .155 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -387 | -2121 | -1645 | -2158 | -2663 | 22 | 310 | 155 |
| Prediction/simulated | 2.244 | 1.826 | .729 | .705 | .780 | .021 | .182 | 0.192 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 21

COMPARISON OF ACOL (TRNMN) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 4, DISCOUNT RATE 10 PERCENT (COLA = CPI - 1%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .323 | .621 | .764 | .878 | .688 | .475 | .357 | .366 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.004 | -.020 | -.029 | -.019 | .011 | .015 | .018 | .030 |
| Predicted effect (ACOL) | -.008 | -.002 | -.010 | -.012 | .003 | -.011 | -.003 | .028 |
| Predicted/simulated | 2.034 | .144 | .360 | .677 | .267 | -.759 | -.186 | .935 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -326 | -701 | -968 | -1119 | -704 | -264 | -21 |
| Predicted effect (ACOL) | 0 | -662 | -433 | -496 | -612 | -414 | -307 | -120 |
| Predicted/simulated | 1 | 2.031 | .618 | .513 | .547 | .588 | 1.162 | 5.714 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -228 | -1530 | -2941 | -3933 | -4435 | -1421 | -467 | 61 |
| Predicted effect (ACOL) | -464 | -2513 | -1767 | -2035 | -2432 | -1362 | -742 | -148 |
| Prediction/simulated | 2.03 | 1.641 | .601 | .517 | .548 | .958 | 1.587 | -2.420 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 22

COMPARISON OF ACOL (TRNMN) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 6, DISCOUNT RATE 10 PERCENT
(Retirement eligibility at YOS 23)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .323 | .621 | .764 | .878 | .688 | .475 | .357 | .366 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.004 | -.023 | -.036 | -.031 | .233 | .157 | -.021 | -.005 |
| Predicted effect (ACOL) | -.002 | -.004 | -.029 | -.055 | .186 | .201 | .015 | -.004 |
| Predicted/simulated | .527 | .173 | .806 | 1.746 | .801 | 1.273 | -.720 | .800 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -396 | -827 | -1152 | -1421 | 1162 | 2046 | 587 |
| Predicted effect (ACOL) | 0 | -209 | -219 | -584 | -1155 | 968 | 2294 | 911 |
| Predicted/simulated | 1 | .529 | .265 | .507 | .813 | .833 | 1.121 | 1.55 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -277 | -1845 | -3474 | -4717 | -5427 | 7528 | 4152 | 897 |
| Predicted effect (ACOL) | -146 | -845 | -1060 | -2567 | -4410 | 6696 | 5457 | 1395 |
| Prediction/simulated | .527 | .458 | .305 | .5443 | .812 | .889 | 1.314 | 1.554 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 23

COMPARISON OF ACOL (TRNMN) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 5 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .323 | .619 | .765 | .887 | .697 | .413 | .298 | .317 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.024 | -.018 | -.021 | -.019 | .027 | .007 | -4E-04 | .005 |
| Predicted/simulated | 1.680 | .361 | .477 | 1.148 | .384 | .087 | -.009 | .200 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -1932 | -1487 | -1533 | -1693 | -924 | -379 | -113 |
| Predicted/simulated | 1 | 1.682 | .778 | .707 | .745 | .984 | -1.869 | -.437 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -1351 | -7464 | -5974 | -6199 | -6699 | -2190 | -806 | -154 |
| Predicted/simulated | 1.680 | 1.477 | .768 | .711 | .748 | 2.675 | -.856 | -.277 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

conditional on the censoring pattern under the current policy. As long as that pattern does not change significantly, this model should do well. But when it changes, the model will not be able to capture the changes in the censoring pattern. The coefficient estimates of this model are presented in Appendix B. Tables 24, 25, 26, and 27 show how well this model predicts simulated responses. They are comparable to Tables 16-19 and 20-23. When YOS dummies are included in the model, the predictions are much better than the QRMC V ACOL. However, although inclusion of the YOS dummies provides better estimates under the current policy than the estimates with the inclusion of the truncated mean variable, the predictions by the ACOL with YOS dummies are not better. In particular, large losses in the early YOS cannot change the retention rates in the later YOS, so the predictions at the later years may overstate the effects of reducing retirement benefits. For example, although the ACOL with YOS dummies predicts the changes in the retention rates in the early YOS better than the model with the taste proxy (truncated mean), the retention rates in YOS 16 in Table 27 are much larger than the actual changes and the predictions with the model that has the taste proxy (in Table 23). This result illustrates the general principle that a good fit to current data does not ensure better predictions under a different retirement system.

Explicitly recognizing that there are two components to the variance in the data (tastes and random shocks) and estimating variance components models may be a better way to deal with the underpredictions of the ACOL model. But such a model would be different from and more complicated than the current ACOL model. Inclusion of such other variables as civilian unemployment rates is also likely to reduce the variance of the random shocks. Therefore, the inclusion of such variables will tend to reduce the biases in the ACOL methodology.

The last limitation of the ACOL model that is quantified is the effect of the ACOL model's being a maximum regret model. Policy changes that do not affect the "best" year to leave the military and the military income opportunities in that year will have no effect on the predicted retention rates from the ACOL model. Such a drastic change as having a flat 50 percent multiplier regardless of YOS will be predicted

Table 24

COMPARISON OF ACOL (YOS DUMMIES) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 10 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .532 | .352 | .190 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.001 | -.004 | -.014 | -.017 | .042 | .066 | .050 | .065 |
| Predicted/simulated | .548 | .276 | .619 | 1.180 | .682 | .918 | 1.143 | 2.322 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -135 | -183 | -352 | -530 | 113 | 579 | 431 |
| Predicted/simulated | 1 | .549 | .342 | .468 | .606 | -10.273 | 1.033 | 1.058 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -94 | -572 | -818 | -1483 | -2065 | 1000 | 1826 | 1046 |
| Predicted/simulated | .548 | .492 | .362 | .484 | .604 | .927 | 1.071 | 1.296 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 25

COMPARISON OF ACOL (YOS DUMMIES) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 4, DISCOUNT RATE 10 PERCENT (COLA = CPI - 1%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .532 | .352 | .190 |
| Simulated effect | -.004 | -.020 | -.029 | -.019 | .011 | .015 | .018 | .030 |
| Predicted effect (ACOL) | -.001 | -.004 | -.011 | -.013 | -.007 | -.016 | -.021 | .049 |
| Predicted/simulated | .449 | .229 | .385 | .703 | -.671 | -1.104 | -1.159 | 1.586 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -326 | -701 | -968 | -1119 | -704 | -264 | -21 |
| Predicted effect (ACOL) | 0 | -146 | -201 | -321 | -455 | -362 | -313 | -186 |
| Predicted/simulated | 1 | .450 | .287 | .332 | .407 | .514 | 1.185 | 8.857 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -228 | -1530 | -2941 | -3933 | -4435 | -1421 | -467 | 61 |
| Predicted effect (ACOL) | -102 | -620 | -866 | -1340 | -1817 | -1532 | -1099 | -185 |
| Predicted/simulated | .449 | .405 | .294 | .340 | .409 | 1.078 | 2.350 | -3.023 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table 26

COMPARISON OF ACOL (YOS DUMMIES) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 6, DISCOUNT RATE 10 PERCENT
(Retirement eligibility at YOS 23)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .532 | .352 | .190 |
| Simulated effect | -.004 | -.023 | -.036 | -.031 | .233 | .157 | -.021 | -.005 |
| Predicted effect (ACOL) | -.001 | -.003 | -.023 | -.059 | .228 | .238 | 3E-04 | 4E-04 |
| Predicted/simulated | .252 | .128 | .638 | 1.878 | .979 | 1.512 | -.011 | -.074 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -396 | -827 | -1152 | -1421 | 1162 | 2046 | 587 |
| Predicted effect (ACOL) | 0 | -100 | -131 | -432 | -1066 | 1618 | 3145 | 1062 |
| Predicted/simulated | 1 | .254 | .159 | .375 | .750 | 1.392 | 1.537 | 1.809 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -277 | -1845 | -3474 | -4717 | -5427 | 7528 | 4152 | 897 |
| Predicted effect (ACOL) | -69 | -424 | -676 | -1985 | -4014 | 8779 | 6424 | 1728 |
| Predicted/simulated | .252 | .230 | .194 | .420 | .739 | 1.166 | 1.547 | 1.925 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table 27

COMPARISON OF ACOL (YOS DUMMIES) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 5 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | | | | | | | | |
| ACOL estimate | .325 | .535 | .853 | .971 | .704 | .474 | .296 | .140 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .704 | .474 | .296 | .140 |
| Simulated effect | .325 | .535 | .853 | .971 | .704 | .474 | .296 | .140 |
| Predicted effect (ACOL) | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted/simulated | -.012 | -.039 | -.056 | -.051 | .078 | .123 | .113 | .147 |
| | .869 | .764 | 1.271 | 3.006 | 1.106 | 1.371 | 2.329 | 5.384 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -997 | -1531 | -2010 | -2461 | -920 | 379 | 524 |
| Predicted/simulated | 1 | .868 | .801 | .927 | 1.083 | .979 | 1.866 | 2.031 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -698 | -4311 | -6367 | -8223 | -9701 | -975 | 2037 | 1597 |
| Predicted/simulated | .869 | .853 | .818 | .943 | 1.083 | 1.192 | 2.163 | 2.859 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

to have almost no effect on retention rates.[10] Table 28 compares the simulated effects of such a change with ACOL predictions. This is a policy where the ACOL performance is at its worst. Furthermore, the improved models discussed above do not perform any better. An additional improvement used a weighted average of the ACOL values for leaving in each of the future decision points rather than the maximum value. The weights were the probability of staying until each of the future decision points for individuals who face similar financial incentives. However, any weighting scheme that does not take tastes into account does not give the desired results. But using tastes in the weighting requires knowledge of the taste distribution. Therefore, the weighting should be done simultaneously with the estimation. That is what the DRM does and that is precisely why it is so difficult to estimate.

In summary, many applications of the ACOL model, such as the QRMC V ACOL, suffer biases due to inadequate modeling of the censoring of tastes and random shocks, and being a maximum regret model. The first two limitations are more important than the last one in most applications. The first two biases work in opposite directions and the net effect is to underpredict the effects of retirement policy changes on retention rates, particularly in the earlier YOS where more individuals are affected. Adding a taste proxy (which is a function of the proportion of an entering cohort still in the military to make a stay/leave decision at a particular decision point) to the ACOL model greatly improves the model's predictive ability. Estimating the model with YOS dummies also reduces the biases in the coefficient of the ACOL variable, but separate estimation of the censoring effects becomes difficult; the model performs well only when the censoring pattern does not vary from the censoring pattern at the estimation period. Inclusion of the taste proxy along with estimation of a variance components model is likely to reduce the biases even further. Any additional variable that explains some of the variance of the random shocks, such as the unemployment rate, is also likely to reduce the biases. The maximum

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[10] A very few individuals who have a bright military but dim civilian future have horizons encompassing more than 20 YOS. Therefore, minor reductions in the retention rates are predicted.

Table 28

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 5, DISCOUNT RATE 10 PERCENT
(Flat multiplier × YOS = 50%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .723 | .740 | .820 | .664 | .376 | .288 | .180 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.002 | -.014 | -.021 | -.012 | -.082 | -.087 | -.018 | .004 |
| Predicted effect (ACOL) | -.001 | -.002 | -5E-04 | -2E-04 | -.043 | -.071 | -.060 | -.001 |
| Predicted/simulated | .457 | .156 | .023 | .013 | .531 | .821 | 3.226 | -.249 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -223 | -489 | -683 | -781 | -1400 | -1308 | -516 |
| Predicted effect (ACOL) | 0 | -101 | -111 | -98 | -96 | -540 | -812 | -489 |
| Predicted/simulated | 1 | .455 | .228 | .144 | .123 | .385 | .620 | .947 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -156 | -1052 | -2055 | -2773 | -3189 | -4433 | -3093 | -837 |
| Predicted effect (ACOL) | -71 | -413 | -440 | -392 | -430 | -2501 | -2440 | -825 |
| Predicted/simulated | .457 | .392 | .214 | .141 | .135 | .564 | .788 | .985 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

regret nature of the model is the most difficult aspect to deal with. Using the probability of staying until a decision point and then leaving at each of the future decision points, where the probabilities are based only on financial incentives and the behavior of the cohort but not specifically on the individual's taste value, did not perform satisfactorily. But simplicity of the estimation of the ACOL model's parameters is one of its major strengths, and it is partly based on resolving the issue of the time horizon for the current stay/leave decision before estimation. Maximum regret models do that. Fortunately, most retirement policies do not affect the second-best time horizon differentially from the best one. Therefore, being a maximum regret model does not prevent ACOL's use in analyzing the effects of most retirement policies.

## LIMITATIONS OF PVCOL AND PPM

The PVCOL model evaluates the financial incentives for the taste-neutral individual and assumes that tastes do not play a role in retention decisions. Therefore, its predicted retention rates are higher than actual retention in the early YOS and lower in the later years. Table 29 shows this and also shows that the PVCOL model underestimates the changes in the retention rates at the first decision point and overpredicts at the later YOS. Once again, the direction of the biases are to be expected because of inadequate modeling of censoring of tastes. Also, the retention rate at the end of the first term (YOS 4) is not affected by the reduction in retirement benefits because PVCOL is a maximum regret model, and in this case the best time horizon for staying in the military does not include the retirement years.

The major problem of the PPM model is in the weighting mechanism used in calculating a weighted average of the cost of leaving measure. Predicted retention rates points are used in weighting the returns from staying until different decision points. But predicted retention rates are conditional probabilities of staying for those who are still in the military to make a stay/leave decision at a particular decision point. Therefore, they are actually higher than the probabilities that should

Table 29

COMPARISON OF PVCOL PREDICTIONS WITH SIMULATED EFFECTS
OF POLICY 2, DISCOUNT RATE 10 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| PVCOL estimate | .430 | .382 | .712 | .928 | .649 | .396 | .302 | .212 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (PVCOL) | 0 | -.010 | -.076 | -.042 | .034 | .055 | .026 | .024 |
| Predicted/simulated | 0 | .645 | 3.270 | 2.854 | .544 | .774 | .610 | .867 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (PVCOL) | 0 | 0 | -347 | -1235 | -1494 | -724 | -110 | 39 |
| Predicted/simulated | 1 | 0 | .647 | 1.640 | 1.707 | 65.818 | -.196 | .095 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (PVCOL) | 0 | -208 | -1833 | -5047 | -5902 | -1215 | 107 | 140 |
| Predicted/simulated | 0 | .179 | .813 | 1.648 | 1.728 | -1.128 | .062 | .173 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

be used by individuals with lower tastes who leave at the earlier decision points. Hence, PPM is likely to overrepresent the effects of far future pay changes. Table 30 confirms that the PPM model overpredicts the retention rate effects of reducing retirement benefits.

## SUMMARY

This section assessed the practical importance of the theoretical limitations of the simpler retention models described in Sec. II. The emphasis was on the ACOL model because it is the most commonly used model to evaluate the effects of alternative retirement policies. The importance of these limitations varies according to discount rate assumptions and retirement policies. In particular, the more the retirement policy to be analyzed differs from the current system, the more important become the ACOL model's biases.

Many applications of the ACOL model, such as QRMC V ACOL, suffer significant biases because of inadequate modeling of the censoring of tastes, random shocks, and being a maximum regret model. The first two limitations are more important than the last in most applications because they work in opposite directions. According to our simulations the net effect is to underpredict the effects of retirement policy changes on retention rates, particularly in the earlier YOS where more individuals are affected. With the types of policies analyzed here, the ACOL model captures *only* about one-quarter to one-third of the changes in the retention rates at YOS 8 and 12.

Adding a taste proxy (which is a function of the proportion of an entering cohort still in the military to make stay/leave decisions at a particular decision point) greatly improves the model's predictive ability. Estimation of a variance components model along with the inclusion of a taste proxy is likely to reduce the biases even further. Any additional variable that explains some of the variance of the random shocks, such as the unemployment rate, is also likely to reduce the biases.

Table 30

COMPARISON OF PPM PREDICTIONS WITH SIMULATED EFFECTS
OF POLICY 2, DISCOUNT RATE 10 PERCENT
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| PPM estimate | .328 | .577 | .736 | .825 | .767 | .505 | .441 | .528 |
| PPM estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (PPM) | -.018 | -.058 | -.079 | -.037 | -.016 | -.006 | -.004 | .010 |
| Predicted/simulated | 6.115 | 3.776 | 3.372 | 2.530 | -.258 | -.096 | -.092 | .380 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (PPM) | 0 | -1509 | -2264 | -2769 | -2960 | -2280 | -1251 | -454 |
| Predicted/simulated | 1 | 6.111 | 4.218 | 3.677 | 3.381 | 207.272 | -2.233 | -1.115 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (PPM) | -1057 | -6491 | -9312 | -11155 | -11774 | -5374 | -2728 | -713 |
| Predicted/simulated | 6.115 | 5.586 | 4.127 | 3.643 | 3.447 | -4.988 | -1.600 | -.885 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

The maximum regret nature of the ACOL model is the most difficult aspect to deal with. Fortunately, most retirement policies do not affect the second-best time horizon differentially from the best time horizon. Therefore, this limitation does not prevent ACOL's use in analyzing the effects of most retirement policies.

# V. SENSITIVITY OF RETENTION MODELS TO INPUT ASSUMPTIONS

The previous section discussed the importance of the theoretical limitations of retention models; however, theoretical limitations are not the only potential sources of error. The assumptions that are made about the inputs to the models, such as the implicit discount rates, could influence the predictions of the retention models. This section quantifies the importance of the assumptions about the inputs to the retention models.

Although this section examines only the ACOL model, the methodology could be applied to other models as well. The influence of the inputs on model predictions depends on the retirement policies analyzed. Three specific alternative retirement systems were analyzed: (1) Policy 2, 1 percent permanent penalty on multiplier for early retirement, (2) Policy 4, COLA protection 1 percentage point less than the CPI, and (3) Policy 5, a flat multiplier of 50 percent independent of YOS. These policies were selected because they differentially affect individuals who leave at different YOS compared with the current policy. Policy 2 penalizes early retirees, Policy 4 penalizes all retirees, and Policy 5 penalizes those who would want to stay in the military for more than 20 years. The ACOL methodology does very poorly in analyzing Policy 5 because it is a maximum regret model. Therefore, analysis of this policy did not contribute much to the results, especially in the earlier YOS.

Section III identified the implicit discount rate, the promotion probabilities, and the civilian income opportunities as potentially the most important inputs to retention models. In the simulation methodology, we know the values of the inputs that were used in individual decisions. Therefore, it is possible to evaluate the effects of incorrect assumptions about the inputs by (1) simulating airmen decisions under one set of assumptions, (2) estimating an ACOL model using the retention rates obtained through the simulation and another set of input assumptions, (3) predicting effects of changing retirement policies by the estimated ACOL, and (4) comparing the simulated responses with the policy change by ACOL's predictions. But because the ACOL methodology could have considerable biases because of its theoretical limitations so the effects of incorrect input assumptions will be evaluated by comparing ACOL predictions under correct and incorrect input assumptions.

If the model were estimated with the correct input assumptions and predictions were made with incorrect assumptions, the biases caused could be easily explained. But when incorrect input assumptions are used in the estimation as well (which is more likely to be the case in practice), then the estimated parameters will be influenced and the effects of incorrect assumptions will be more difficult to evaluate on a theoretical basis alone. Some practitioners ignore the problem of incorrect input assumptions by assuming that the model parameters will fully adjust for the input errors. The strength of the simulation methodology is due to knowledge of the correct input values.

## IMPLICIT DISCOUNT RATES

The difficulty of estimating the implicit discount rate that airmen use in their stay/leave decisions comes from not being able to observe individuals' decisions under compensation systems that differ in their deferred earnings component. Because the implicit discount rate is an integral component of the valuation of different earnings profiles, several types of biases were evaluated that may arise in practice. First, the discount rate may be underestimated. Second, it may be overestimated. Third, the actual discount rate may be independent of YOS, but a tapered discount rate may be used in estimating the ACOL model. Finally, the actual discount rate may be declining by age (or YOS), but a flat discount rate may be used in estimating the model.

For the first case, airmen's decisions were simulated using a 10 percent discount rate and the ACOL model estimated using a 5 percent discount rate. When a smaller discount rate is used, the importance of future pays will be overstated. Therefore, the proportion of the simulated effects captured by the ACOL should increase. Table 31 shows

Table 31

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF DISCOUNT RATES AND WITH SIMULATED EFFECTS OF POLICY 2, ACTUAL DISCOUNT RATE 10 PERCENT, ASSUMED RATE 5 PERCENT

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual (10%) | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .723 | .740 | .820 | .664 | .376 | .288 | .180 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.001 | -.002 | -.007 | -.008 | .022 | .036 | .027 | .033 |
| Predicted/simulated | .444 | .188 | .330 | .578 | .364 | .504 | .616 | 1.193 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -109 | -136 | -217 | -304 | 19 | 297 | 227 |
| Predicted/simulated | 1 | .443 | .255 | .289 | .348 | -1.727 | .530 | .557 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -76 | -453 | -588 | -907 | -1188 | 523 | 964 | 532 |
| Predicted/simulated | .444 | .390 | .261 | .296 | .348 | .485 | .565 | .659 |
| Lower (5%) | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .686 | .744 | .862 | .677 | .389 | .291 | .165 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.003 | -.011 | -.017 | -.015 | .021 | .037 | .029 | .040 |
| Predicted/simulated | 1.263 | .737 | .740 | 1.033 | .347 | .516 | .668 | 1.435 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -310 | -465 | -613 | -750 | -383 | 75 | 152 |
| Predicted/simulated | 1 | 1.259 | .867 | .814 | .857 | 34.818 | .133 | .373 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -218 | -1336 | -1937 | -2509 | -2960 | -339 | 558 | 448 |
| Predicted/simulated | 1.263 | 1.149 | .859 | .819 | .866 | -.315 | .327 | .555 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

the comparison of ACOL predictions with the correct discount rate assumption (the top half of the table) and with a lower discount rate (5 percent) than the one used in simulating airmen's decisions. The ACOL's predictions of retention effects almost triple in the earlier YOS with a smaller discount rate.[1]

Similarly, for the second case, airmen's decisions were simulated using a 5 percent discount rate and the ACOL model estimated using a 10 percent discount rate. In this case the model should pick up a smaller proportion of the simulated effects. Table 32 shows that the ACOL's predictions of the changes in retention rates are more than halved with a larger discount rate.

For the third case, airmen's decisions were simulated using a discount rate of 10 percent; but the ACOL model was estimated by assuming a tapered discount rate that reduces exponentially from 20 percent at YOS 4 to 2 percent at YOS 30. Table 33 show the results assuming a tapered discount rate when the discount rate is actually flat. When the discount rate is tapered between 20 percent and 2 percent, the ACOL values are smaller in the early YOS than with a 10 percent discount rate. At the later YOS this situation changes. Table 33 shows that using a tapered discount rate when the actual discount rate is flat results in a positive bias at the early YOS and a negative bias in the later YOS. That is, the proportion of the simulated effects picked up by the ACOL model increases at the early YOS when ACOL values are calculated with a discount rate assumption. In the later YOS this proportion declines.

Finally, Table 34 shows the effects of assuming a flat 10 percent discount rate in estimating the ACOL model when the actual discount rate was tapered from 20 percent to 2 percent. These results are similar those in Table 33. When the discount rate is exponentially tapered between 20 percent and 2 percent from YOS 4 to YOS 30, the proportion of the simulated effects picked up by the ACOL model are larger than the proportion with a 10 percent discount rate assumption.

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[1]For other policies, the effect of underestimating the discount rate is similar to the reported effect in Table 31.

Table 32

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF DISCOUNT RATES AND WITH SIMULATED EFFECTS OF POLICY 2, ACTUAL DISCOUNT RATE 5 PERCENT, ASSUMED RATE 10 PERCENT

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual (5%) | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.005 | -.014 | -.016 | -.010 | .024 | .042 | .035 | .039 |
| Predicted/simulated | .360 | .271 | .360 | .604 | .338 | .477 | .733 | 1.442 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -413 | -584 | -712 | -808 | -310 | 191 | 201 |
| Predicted/simulated | 1 | .360 | .305 | .328 | .355 | .330 | .940 | .779 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -289 | -1758 | -2403 | -2886 | -3183 | -189 | 752 | 467 |
| Predicted/simulated | .360 | .348 | .309 | .331 | .355 | .231 | .798 | .836 |
| Higher (10%) | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .709 | .728 | .818 | .645 | .360 | .279 | .164 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.002 | -.005 | -.007 | -.005 | .025 | .042 | .032 | .032 |
| Predicted/simulated | .173 | .103 | .177 | .345 | .361 | .470 | .672 | 1.206 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -199 | -247 | -317 | -379 | 21 | 357 | 244 |
| Predicted/simulated | 1 | .173 | .129 | .146 | .167 | -.022 | 1.758 | .945 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -139 | -826 | -1026 | -1295 | -1480 | 628 | 1086 | 510 |
| Predicted/simulated | .173 | .163 | .132 | .148 | .165 | -.767 | 1.154 | .913 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table 33

COMPARISON OF ACOL (ARMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF DISCOUNT RATES AND WITH SIMULATED EFFECTS OF POLICY 2, ACTUAL DISCOUNT RATE 10 PERCENT, ASSUMED RATE TAPERED

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual (10%) | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .723 | .740 | .820 | .664 | .376 | .288 | .180 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.001 | -.002 | -.007 | -.008 | .022 | .036 | .027 | .033 |
| Predicted/simulated | .444 | .188 | .330 | .578 | .364 | .504 | .616 | 1.193 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -109 | -136 | -217 | -304 | 19 | 297 | 227 |
| Predicted/simulated | 1 | .443 | .255 | .289 | .348 | -1.727 | .530 | .557 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -76 | -453 | -588 | -907 | -1188 | 523 | 964 | 532 |
| Predicted/simulated | .444 | .390 | .261 | .296 | .348 | .485 | .565 | .659 |
| Tapered (20%-2%) | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .692 | .732 | .846 | .700 | .396 | .288 | .161 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.001 | -.006 | -.012 | -.013 | .014 | .030 | .025 | .038 |
| Predicted/simulated | .577 | .446 | .548 | .888 | .224 | .417 | .578 | 1.351 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -141 | -256 | -385 | -514 | -178 | 137 | 158 |
| Predicted/simulated | 1 | .575 | .479 | .512 | .587 | 16.181 | .244 | .388 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -99 | -637 | -1093 | -1594 | -2029 | -220 | 510 | 410 |
| Predicted/simulated | .577 | .548 | .484 | .520 | .594 | -.205 | .299 | .508 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table 34

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF DISCOUNT RATES AND WITH SIMULATED EFFECTS OF POLICY 2, ACTUAL DISCOUNT RATE TAPERED, ASSUMED RATE 10 PERCENT

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual (20%-2%) | | | | | | | | |
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.012 | -.062 | -.035 | -.003 | .115 | .110 | .076 | .054 |
| Predicted effect (ACOL) | -.003 | -.011 | -.006 | -5E-04 | .018 | .030 | .040 | .047 |
| Predicted/simulated | .236 | .176 | .195 | .163 | .159 | .275 | .523 | .881 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -1015 | -2185 | -2496 | -2527 | -533 | 725 | 769 |
| Predicted effect (ACOL) | 0 | -240 | -426 | -500 | -505 | -120 | 227 | 331 |
| Predicted/simulated | 1 | .236 | .195 | .200 | .200 | .225 | .313 | .431 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -710 | -4764 | -8897 | -9998 | -9912 | 724 | 2780 | 1662 |
| Predicted effect (ACOL) | -167 | -1074 | -1743 | -2003 | -1986 | 117 | 989 | 845 |
| Predicted/simulated | .236 | .225 | .195 | .200 | .200 | .162 | .355 | .508 |
| Flat (10%) | | | | | | | | |
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .755 | .778 | .875 | .681 | .429 | .328 | .190 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.012 | -.062 | -.035 | -.003 | .115 | .110 | .076 | .054 |
| Predicted effect (ACOL) | -.002 | -.006 | -.004 | -3E-04 | .031 | .040 | .042 | .044 |
| Predicted/simulated | .195 | .098 | .133 | .110 | .276 | .369 | .553 | .825 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -1015 | -2185 | -2496 | -2527 | -533 | 725 | 769 |
| Predicted effect (ACOL) | 0 | -197 | -274 | -326 | -329 | 192 | 534 | 463 |
| Predicted/simulated | 1 | .194 | .125 | .130 | .130 | .360 | .736 | .602 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -710 | -4764 | -8897 | -9998 | -9912 | 724 | 2780 | 1662 |
| Predicted effect (ACOL) | -138 | -836 | -1126 | -1309 | -1268 | 1183 | 1786 | 1045 |
| Predicted/simulated | .195 | .175 | .126 | .130 | .128 | 1.633 | .642 | .628 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

## PROMOTION PROBABILITIES

The most likely error in the promotion probabilities happens when an analyst cannot identify the individuals who inherently have a higher or lower likelihood of being promoted than the average personnel and uses average promotion probabilities in calculating returns to staying in the military for everybody. This is the incorrect assumption that will be discussed.[2]

When an analyst uses average promotion probabilities for each individual, it is equivalent to assuming that differences among individuals (which may be known to the individuals) are random events. Hence, using average promotion probabilities will increase the variance of the random shocks. This in turn will increase the downward bias in the coefficient of the ACOL variable, as discussed in Secs. II and IV. Table 35 compares the estimated standard deviation of tastes (the reciprocal of the coefficient of ACOL) when the actual promotion probabilities are known and when they are assumed to be average for everybody. As expected, the bias in estimating the standard deviation of tastes grows.

Underestimation of the effects of retirement policies will be more serious when the differences in promotion opportunities cannot be identified (if these differences are known to the individuals). Table 36 confirms this argument. The proportion of the simulated effect that the ACOL model captures gets reduced when average rather than actual promotion probabilities are used. Nevertheless, the net effect of using the average does not seem to be very large.

Another effect of using average promotion probabilities is that under some assumptions the best time horizon for airmen in their early YOS does not encompass the 20th YOS, and it may encompass YOS 20 for

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[2] In these simulations there are three groups of individuals with respect to promotion probabilities: (1) the high promotion probability group, which has 10 percent higher promotion probability than the average person; (2) the average promotion probability group; and (3) the low promotion probability group, which has a 10 percent lower promotion probability. Also, as in many applications in the ACOL model, a median promotion path is used for each identified group rather than probabilities. Nevertheless, the median promotion path for a group will be a function of their inherent promotion probabilities.

Table 35

COMPARISON OF THE ACTUAL STANDARD DEVIATION OF TASTES WITH ESTIMATED STANDARD DEVIATIONS FROM ACOL (QRMC V) MODELS WITH PERFECT AND IMPERFECT KNOWLEDGE OF PROMOTION PROBABILITIES

| Discount Rate | Actual Standard Deviation of Tastes | ACOL's Estimate (actual probabilities) | ACOL's Estimate (average probabilities) |
|---|---|---|---|
| 10%[a] | 5001 | 9900 | 10500 |
| 5%[b] | 2001 | 11700 | 12600 |
| 20%-2%[c] | 2001 | 13200 | 13850 |

[a]Tastes are distributed according to $N(0,5001^2)$, random shocks are distributed according to $N(0,30000^2)$.

[b]Tastes are distributed according to $N(500,2001^2)$, random shocks are distributed according to $N(0,40000^2)$.

[c]Tastes are distributed according to $N(1000,2001^2)$, random shocks are distributed according to $N(0,26000^2)$.

those with high promotion probabilities. Therefore, using average promotion probabilities may further reduce ACOL's responsiveness to retirement policy changes. However, this effect was not significant.

As Ward and Tan (1984) showed, the inherent promotability differences among individuals could be better identified when observed through several promotions. Therefore, average promotion probabilities are more likely to be used in the earlier YOS and this difficulty is more likely to be encountered at the early YOS.[3]

## CIVILIAN INCOME OPPORTUNITIES

Inability to identify individual differences in civilian income opportunities is the first difficulty analysts face. Another problem comes from selection biases in the data on post-service earnings of military separatees and retirees. Because individuals who have high civilian income opportunities are more likely to leave the military

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[3]Pooling data across YOS for estimation will carry this bias to later YOS as well.

Table 36

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF PROMOTION PROBABILITIES AND WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 10 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Promotion Probability | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .723 | .740 | .820 | .664 | .376 | .288 | .180 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.001 | -.002 | -.007 | -.008 | .022 | .036 | .027 | .033 |
| Predicted/simulated | .444 | .188 | .330 | .578 | .364 | .504 | .616 | 1.193 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -109 | -136 | -217 | -304 | 19 | 297 | 227 |
| Predicted/simulated | 1 | .443 | .255 | .289 | .348 | -1.727 | .530 | .557 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -76 | -453 | -588 | -907 | -1188 | 523 | 964 | 532 |
| Predicted/simulated | .444 | .390 | .261 | .296 | .348 | .485 | .565 | .659 |
| Average | | | | | | | | |
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .326 | .724 | .741 | .817 | .669 | .378 | .292 | .188 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .351 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -9E-04 | -.002 | -.007 | -.008 | .022 | .035 | .027 | .032 |
| Predicted/simulated | .290 | .134 | .301 | .537 | .353 | .490 | .614 | 1.157 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -72 | -92 | -175 | -255 | 48 | 304 | 228 |
| Predicted/simulated | 1 | .292 | .172 | .233 | .291 | -4.363 | .542 | .560 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -49 | -301 | -411 | -736 | -990 | 570 | 965 | 528 |
| Predicted/simulated | .290 | .259 | .182 | .240 | .290 | .529 | .566 | .654 |

[a]95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

service than those with average or low opportunities, the data on post-ervice earnings will be biased upward. Therefore, the second incorrect assumption evaluated is the effect of upward biases in civilian income opportunities.

As with the promotion probabilities, the net effect of using average civilian income opportunities instead of individual opportunities will be to increase the variance of random shocks, which in turn increases the downward bias in the coefficient of the ACOL variable. Table 37 compares the estimates of the standard deviation of tastes (inverse of the coefficient of the ACOL variable) with average and actual civilian income opportunities. Using average civilian income opportunities worsens the estimates of the standard deviation of tastes more than using average promotion probabilities because a 10 percent increase in promotion probabilities does not get translated into a 10 percent increase in pay.

Table 37

COMPARISON OF THE ACTUAL STANDARD DEVIATION OF TASTES WITH ESTIMATED STANDARD DEVIATIONS FROM ACOL (QRMC V) MODELS WITH PERFECT AND IMPERFECT KNOWLEDGE OF CIVILIAN INCOME OPPORTUNITIES

| Discount Rate | Actual Standard Deviation of Tastes | ACOL's Estimate (actual civilian opportunities) | ACOL's Estimate (average civilian opportunities) |
|---|---|---|---|
| 10%[a] | 5001 | 9900 | 11100 |
| 5%[b] | 2001 | 11700 | 13900 |
| 20%-2%[c] | 2001 | 13200 | 14600 |

[a]Tastes are distributed according to $N(0,5001^2)$, random shocks are distributed according to $N(0,30000^2)$.

[b]Tastes are distributed according to $N(500,2001^2)$, random shocks are distributed according to $N(0,40000^2)$.

[c]Tastes are distributed according to $N(1000,2001^2)$, random shocks are distributed according to $N(0,26000^2)$.

Table 38 confirms that with use of average civilian income opportunities, the ACOL predictions for retirement policy changes will understate the actual effects. Similar analyses with other retirement policies and discount rate assumptions do not change this conclusion.

Using upwardly biased average civilian income opportunities has two effects. First, it is equivalent to increased variance of random shocks. Second, it decreases the value of cost of leaving measures. Furthermore, the reduction in the cost of leaving measure will be larger at the earlier YOS than at the later YOS because the more an individual stays with the military the less transferable his experience will be to the civilian sector employment. His civilian income opportunities will therefore be reduced. A proportionate increase in the civilian income opportunities (the upward bias) will have a larger effect on reducing the cost of leaving at the early YOS. Table 39 shows that this kind of upward bias reduces the effectiveness of ACOL methodology (the proportion of the simulated effect captured by the ACOL model) even further.

## SUMMARY

This section analyzed the effects of potential empirical difficulties in preparing the inputs to the retention models. The assumptions made in calculating the cost of leaving measures could have large effects on ACOL predictions. Biases in the input assumptions would be translated into biases in the predictions. In particular, the predictive capability of the ACOL model is sensitive to the assumptions about the discount rates. Then in order of importance, the assumptions about civilian income opportunities and promotion probabilities could influence the predictive capability of the ACOL model.

The biases caused by the empirical difficulties in input preparation are not limited to the ACOL model. As Ascher (1978) put it, even the results of the most technically sophisticated models are often driven by simple inputs that receive far less formal analytical attention than the models themselves. Nevertheless, with the exception of the errors in the discount rate assumptions, the theoretical limitations of the ACOL methodology seem to be more important than the biases caused by input preparations.

Table 38

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH PERFECT AND IMPERFECT KNOWLEDGE OF CIVILIAN INCOME OPPORTUNITIES AND WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 5 PERCENT
(1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Civilian Income Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.005 | -.014 | -.016 | -.010 | .024 | .042 | .035 | .039 |
| Predicted/simulated | .360 | .271 | .360 | .604 | .338 | .477 | .733 | 1.442 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -413 | -584 | -712 | -808 | -310 | 191 | 201 |
| Predicted/simulated | 1 | .360 | .305 | .328 | .355 | .330 | .940 | .779 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -289 | -1758 | -2403 | -2886 | -3183 | -189 | 752 | 467 |
| Predicted/simulated | .360 | .348 | .309 | .331 | .355 | .231 | .798 | .836 |
| Average | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .688 | .740 | .851 | .677 | .382 | .287 | .167 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .296 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.003 | -.011 | -.013 | -.008 | .021 | .036 | .030 | .034 |
| Predicted/simulated | .271 | .223 | .297 | .495 | .299 | .406 | .636 | 1.245 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -312 | -467 | -576 | -656 | -230 | 182 | 178 |
| Predicted/simulated | 1 | .272 | .244 | .266 | .289 | .244 | .896 | .689 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -218 | -1344 | -1925 | -2337 | -2583 | -81 | 681 | 411 |
| Predicted/simulated | .271 | .266 | .247 | .268 | .288 | .099 | .723 | .736 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table 39

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH ACTUAL AND UPWARDLY BIASED CIVILIAN INCOME OPPORTUNITIES AND WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 5 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Civilian Income Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Actual | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.005 | -.014 | -.016 | -.010 | .024 | .042 | .035 | .039 |
| Predicted/simulated | .360 | .271 | .360 | .604 | .338 | .477 | .733 | 1.442 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -413 | -584 | -712 | -808 | -310 | 191 | 201 |
| Predicted/simulated | 1 | .360 | .305 | .328 | .355 | .330 | .940 | .779 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -289 | -1758 | -2403 | -2886 | -3183 | -189 | 752 | 467 |
| Predicted/simulated | .360 | .348 | .309 | .331 | .355 | .231 | .798 | .836 |
| Upward Bias | | | | | | | | |
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .678 | .733 | .850 | .678 | .388 | .301 | .167 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .296 | .140 |
| Simulated effect | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Predicted effect (ACOL) | -.001 | -.008 | -.013 | -.008 | .023 | .042 | .038 | .038 |
| Predicted/simulated | .126 | .172 | .295 | .511 | .328 | .472 | .790 | 1.392 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Predicted effect (ACOL) | 0 | -144 | -311 | -441 | -531 | -116 | 286 | 246 |
| Predicted/simulated | 1 | .125 | .162 | .203 | .234 | .123 | 1.408 | .953 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| Predicted effect (ACOL) | -101 | -677 | -1313 | -1801 | -2085 | 209 | 927 | 532 |
| Predicted/simulated | .126 | .134 | .168 | .206 | .232 | -.255 | .984 | .952 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

# VI. POLICY ANALYSIS OF RETIREMENT PLANS

This section first reviews some of the policy analytic issues that were raised in Section I. Then it demonstrates the value of detailed analyses of the retention effects of alternative retirement plans.

## THE IMPORTANCE OF RETENTION MODELS

Evaluation of alternative retirement policies should consider both the cost and the military readiness effects. As discussed earlier, most proposed alternative retirement systems have emphasized cost savings. But any change to the retirement system also affects the incentives of military personnel to stay with the military. This has two important effects: First, it changes the total cost of the system by changing the number of personnel in each grade and YOS who are receiving military compensation; second, changes in military manpower affect military readiness (Fig. 6). Therefore, cost alone is not an adequate criterion for evaluating alternative systems; effects on military readiness should also be considered.

The retention models could be used in two modes. The force profiles that would result under alternative retirement policies could be estimated to evaluate the cost and military readiness effects for a cost benefit analysis. The more difficult problem of comparing the

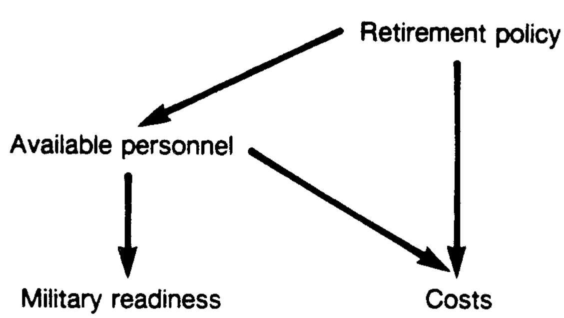


Fig. 6 -- Retirement policies affect both costs and military readiness

readiness effects of different force profiles could be side-stepped by searching for compensation packages[1] that can produce the same overall force profile as the current one. The second approach is equivalent to evaluating the cost effectiveness of different components of the military compensation system. It will limit the packages that could be considered because a necessary condition is that the value of military compensation as seen by the military personnel should be the same as the value of the current compensation package.[2]

The cost of alternative retirement systems has two components: the amounts that will be paid to those who will retire from a given cohort (the deferred payments) and the current compensation. Accurate computation of both components requires estimation of the retention effects. The best measure of the deferred payments component is the accrual rate--the percentage of active duty basic pay that would have to be set aside to fund future retirement liabilities of current personnel.[3] This is because current outlays for retirement pay reflect the consequences of past policies and understate the long term cost implications of changing the retirement system (especially if the current members are grandfathered). One of the most important inputs to the calculation of accrual costs is the *estimated fraction* of an entering cohort that will remain in the military until various YOS and then leave. The distribution of the losses from an entering cohort at each YOS can be estimated by a behavioral retention model. Once this distribution, the schedule of retirement annuities, and the interest rate on invested funds are known, the calculation of the accrual rate becomes straightforward. When the retention rates change because of a

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[1]An alternative compensation package does not limit the potential changes to the retirement component; other elements of the compensation system, such as bonuses, could also be changed.

[2]QRMC V used the second approach. The most important input in such evaluations is the discount rate. Given the empirical difficulties of estimating the implicit discount rates, policies obtained through such a procedure could end up having major effects on readiness.

[3]The Congressional Budget Office estimated the accrual rate of the current system to be 48.9 percent of basic pay (CBO, 1984).

change in the retirement system, the other elements of military compensation will also be affected. Therefore, changes in the current outlays for active duty pay should also be considered in analyzing the cost effects of retirement policies. Again, this could be done with a behavioral retention model to estimate the retention rates and by calculating the amount of current compensation that has to be paid to those who stay.

The analysis of the effects of different force profiles on military readiness is a complex subject. First of all, manpower is only one dimension; available equipment and the nature of the threat also affect readiness. Second, military personnel are not homogeneous. They belong to different occupational groups, and they have different experience and quality levels. The evaluation of the effects of various retirement policies on military readiness is outside the scope of this work and it could best be done by the management of the military who are knowledgeable about the personnel-equipment interactions and the probabilities of different types of threats. Nevertheless, reliable estimates of retention effects of alternative policies are crucial inputs to such evaluations.

The previous section examined the retention effects of different retirement policies by concentrating on the retention rates by years of service. However, further disaggregation of the retention effects by grade, occupational group, and quality levels is essential for accurate assessment of cost and military readiness effects. First, military pay is a function of YOS and grade. Hence, accurate prediction of cost effects requires, at the minimum, disaggregation by these two components. Second, personnel in different occupations with different quality and experience levels[4] are likely to have different productivity levels in terms of military readiness (Fig. 7). Concentrating on only the retention effects of alternative policies may disguise large gains in one group with large losses in another. Because of the differences in the productivities of these groups, important military readiness effects may go unnoticed unless disaggregate analysis is conducted.

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[4]See Ward and Tan (1984) for operationalizing the concept of quality.

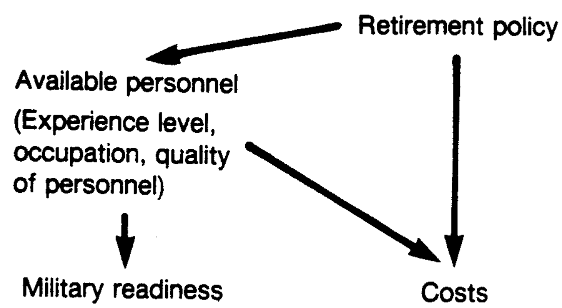


Fig. 7 -- "Who" is as important as "how many"

Third, differential effects of a policy change by separate groups of personnel are important in evaluating the equity aspects of policy changes. Equity is an important principle in military compensation, and disaggregation of the effects of policy changes is necessary in evaluating the conformity of different retirement policies to the concept of "equal pay for substantially equal work."

Furthermore, the sensitivity of military personnel to compensation levels may also be a function of their occupation or quality level. That is, those in administrative occupations may behave differently than those in combat occupations under similar compensation schemes. Therefore, a disaggregate look at the force may provide more accurate predictions of retention rates.[5]

## AGGREGATE RETENTION EFFECTS

The results in the remainder of this section are based on the simulation methodology explained in Sec. III. The Dynamic Retention Model, which the simulations were based on, have not been estimated, but a calibration methodology was used to obtain parameters that enable the simulations to mimic the observed retention rates between 1971 and 1981.[6] Therefore, the results here should be taken as indicative of the

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[5]This requires separate estimation of the retention models for different occupational groups rather than using different compensation level inputs for each occupation. If a particular relationship between the sensitivities of different groups is specified, separate estimation may not be required.

[6]Also, the implicit discount rate parameter was not estimated

expected retention effects of alternative retirement policies, rather than as actual predictions.[7] Considering the magnitude of the biases in the most commonly used model, ACOL, predictions from a *calibrated*, theoretically "correct" model may be more informative than predictions from an *estimated* model with large biases. The ACOL model captures only one-quarter to one-third of the reduction in retention rates under certain policies at YOS 8 and 12, the years that count the most. Retention rates at these years are very important because many personnel are affected in those years. Also, those who stay past those decision points usually stay until YOS 20, so any individual lost at those decision points is equivalent to a loss of 8 to 12 manyears.

The simulations use the years served in the military as the proxy for experience level. The differences in promotion probabilities (not the actual promotion rate) among individuals are proxies for quality levels. Different civilian income opportunities and bonuses were used as proxies for occupational groups. The retention rates and costs are most heavily influenced by YOS. Also, personnel with different experience levels are likely to have different productivity levels; those with high YOS tend to occupy managerial positions, which are quite different from positions held by more junior personnel. Therefore, the minimum level of detail required in analysis of retirement policies involves distribution of retention rates by YOS (aggregate analysis).

Policy 2 has a 1 percentage point permanent reduction in the multiplier for each year of early retirement before YOS 30. Appendix C provides the analysis of the policies explained in Sec. IV. Table 40 shows the aggregate retention effects of this policy change (Policy 2) compared with the current policy (Policy 1) by YOS and different discount rate assumptions. The effects are presented with three different measures. The base case retention rates, the proportion of airmen staying at a particular decision point, and the changes caused by the new policy are given in the first two rows of each discount rate

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because of insufficient variation between the deferred and current pay components of the compensation system during the estimation period. But three different assumptions were used to analyze the sensitivity of results to discount rate assumptions.

[7]The same holds for Appendix C.

Table 40

COMPARISON OF SIMULATED RETENTION RATES UNDER THE CURRENT POLICY AND POLICY 2, VARIOUS DISCOUNT RATES
(1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| Effect of Policy 2 | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 2 | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 2 | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| Effect of Policy 2 | -.014 | -.052 | -.044 | -.017 | .071 | .090 | .048 | .027 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 2 | 0 | -1148 | -1912 | -2167 | -2271 | -939 | 203 | 258 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 2 | -803 | -5052 | -7776 | -8711 | -8951 | -818 | 941 | 558 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 2 | -.012 | -.062 | -.035 | -.003 | .115 | .110 | .076 | .054 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 2 | 0 | -1015 | -2185 | -2496 | -2527 | -533 | 725 | 769 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 2 | -710 | -4764 | -8897 | -9998 | -9912 | 724 | 2780 | 1662 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column is very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

assumption. Then snapshots of the number of airmen present at the beginning of each term (or three year periods during the retirement years)[8] and the changes due to the new policy are given in the following two rows. Finally the number of manyears in a term and the change in this number are presented in the last two rows under different discount rate assumptions.[9]

Two generalizable (to other policies) observations can be made from Table 40. First, both retention rates and the changes in the retention rates across YOS vary considerably. Therefore, if any productivity gains are due to experience then YOS is an important dimension to consider in retirement policy analysis. Second, the assumed implicit discount rate has a large influence on the effects of a policy change. In particular, as the discount rate decreases the weight given to retirement benefits increases (even in the early YOS). Therefore, any change in the retirement benefits has a greater effect when the implicit discount rate is smaller. An equivalent flat discount rate for a tapered discount rate between 20 and 2 percent (from YOS 4 to YOS 30, especially at the early YOS) is closer to 10 percent than 5 percent.[10] But despite that, with the tapered discount rate assumption, the effects of a change in the retirement policy are greater than the effects under a 10 percent discount rate assumption because with a tapered discount rate a larger part of the increased retention rate until YOS 20 is attributed to the retirement benefits.

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[8]During the retirement years individuals are simulated to make a decision every year (if they have not accepted a promotion to E-7 or higher in the last two years), but the tables show the total responses within a three year period for expositional clarity.

[9]In the simulations, airmen make decisions only at the end of each term or year after YOS 20. Therefore, manyears were calculated by assuming that the distribution of the losses during the term (or year) follows a pattern similar to the patterns observed between 1971 and 1981. See Sec. IV for more detail.

[10]For a given pattern of an income stream (say the current military compensation), an equivalent flat discount rate could be calculated for any tapered discount rate assumption, where equivalence is defined by equating the present values obtained from each discount rate assumption.

More specifically for Policy 2, Table 40 shows that reducing the multiplier for early retirees decreases the retention, especially at the earlier YOS. With the tapered and 5 percent discount rate assumptions, the reduction in the number of manyears served by personnel between YOS 8 and 20 could be as large as 20 percent of the total manyears served by similar personnel under the current policy. With a 10 percent discount rate assumption, the magnitude of the extra losses drops to about 5 to 10 percent of the current manyears between YOS 8 and 20. Therefore, fewer airmen reach retirement eligibility under Policy 2. However, the number of manyears served by personnel with YOS 20 to 30 increases when there is a penalty for early retirement because airmen with a high taste for the military constitute a majority of the force in the retirement years under the current policy. These same people are also least sensitive to changes in military pay and, therefore, most likely to stay until retirement eligibility under the new policy. Under the 10 percent discount rate assumption in Table 40, although the number of airmen reaching retirement eligibility (very close to the number of airmen starting the period between YOS 17-20) is smaller under Policy 2, the number of airmen who stay past 20 YOS (the number of airmen starting to serve the period YOS 21-23) is essentially the same under Policy 2. But after the 20 YOS point, under Policy 2 the incentives for staying longer increase. The multiplier increases at a rate of 3.5 percentage points per year under the new policy rather than 2.5 percentage points under the current policy. Therefore, if the end-strength is kept at a constant level, the proportion of very junior (less than 4 YOS) and very senior (greater than 20 YOS) personnel will increase.[11]

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[11]The simulations did not change the promotion policies with different retirement policies. However, fewer airmen between the 10th and 20th YOS (under the penalty for early retirement) may lead to increased promotion rates to fill certain positions. Because the proportion of high taste airmen increases as the cohort ages, this will lead to more of them being promoted than under the current policy and fewer of them will be forced out because of HYT policies. Hence, increasing the promotion rates as a response to lower retention will further increase the retention at the retirement years.

Although fewer airmen reaching retirement eligibility would reduce the cost of the retirement fund, the increase in the number of very senior personnel will have a compensatory effect. The calculation of the net effect requires a cost model.[12] Military readiness effects of having a larger junior force with fewer middle managers and more senior managers than the current system should also be evaluated to determine the desirability of this retirement plan.

## DISAGGREGATION OF THE RETENTION EFFECTS

Two factors drive the differences in the effects of a policy change across groups of airmen with different characteristics. First, if the retention rate at a particular decision point is very high or very low, then the effect of a compensation policy change is likely to be small, other things equal,[13] because a very high retention rate means that the financial incentives offered are already too high for many individuals and only those with very low tastes for the military leave.[14] Therefore, a change in the compensation is likely to leave the financial incentives high enough for many individuals so they will not change their stay decision. Similarly, if the retention rate is very low, the financial incentives are too low for many individuals and only those with very high tastes stay in the military. Therefore, a change in the retirement system is unlikely to influence the decisions of many individuals. However, if the retention rate is closer to the mode of the taste distribution, more individuals are making close calls between staying and leaving. Therefore, a change in the retirement system is likely to influence more individuals' decisions.

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[12]Like the cost model that is being developed for the EFMS by C. Peter Rydell of The Rand Corporation.

[13]This argument assumes the unimodality of the taste distribution. It also assumes that the probability density function of tastes will increase monotonically with tastes until the mode and decrease monotonically with tastes thereafter (that is, the probability of an individual having very high or very low tastes toward military life is less than the probability of having a taste value closer to the one most commonly observed).

[14]Random shocks may also influence decisions, but for simplifying the argument let us abstract from this consideration.

Second, if the retention rates at the *earlier* decision points were *low*, the effect of a policy change is likely to be *smaller* than otherwise, other things equal, because low retention rates at the earlier decision points mean that those who stayed did so despite low financial incentives (many others who faced similar financial incentives left). Therefore, those who stayed despite low incentives are likely to have very high tastes for military life and their decisions are less likely to be swayed by changes in the compensation system. For individuals who persistently face financial incentives different from those of the rest of their cohort, the first and the second factors will be working in opposite directions.

## Differential Effects by Civilian Income Opportunities

Table 41 shows that those who have higher civilian income opportunities leave the military at a greater rate than those who have lower civilian opportunities. But because of their lower retention rates, the penalty from the early retiree multiplier does not reduce their retention rates as much as it does the others in YOS 4 and YOS 8. By YOS 12, a large proportion of those with high civilian opportunities have already left the military, and the remaining individuals from this group have higher tastes for the military than individuals who had lower civilian opportunities. Also, the retention rate for this group at YOS 12 is closer to the 50th percentile than for other groups. The net result of these two factors is to have Policy 2 reduce the retention rate of persons in this group more than it reduces the retention rate of persons in the other two groups at YOS 12. Further evidence on the effect of these two factors is provided in Appendix C, under the analysis of Policy 4 (COLA + CPI - 1%), where the net result is to reduce the retention rate of persons in this group less than the retention rate of persons in the other two groups.

Comparison of the retention rates of individuals with different civilian opportunities shows that a lower discount rate (Table 41) causes a larger variance among the retention rates of groups with different civilian opportunities than a higher discount rate (Table 42). A smaller discount rate causes financial incentives to be more influential on airmen's decisions than a higher rate.

Table 41

COMPARISON OF RETENTION EFFECTS BY DIFFERENT CIVILIAN INCOME OPPORTUNITIES, POLICY 2, DISCOUNT RATE 5 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Civilian Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| High[a] | | | | | | | | |
| Retention rate (current) | .218 | .274 | .717 | .935 | .636 | .420 | .261 | .058 |
| Effect of Policy 2 | -.005 | -.031 | -.079 | -.019 | .107 | .068 | .007 | .107 |
| Average[b] | | | | | | | | |
| Retention rate (current) | .318 | .502 | .829 | .968 | .685 | .458 | .298 | .146 |
| Effect of Policy 2 | -.014 | -.054 | -.052 | -.019 | .074 | .097 | .053 | .032 |
| Low[c] | | | | | | | | |
| Retention rate (current) | .468 | .736 | .931 | .983 | .765 | .533 | .339 | .175 |
| Effect of Policy 2 | -.022 | -.047 | -.023 | -.013 | .064 | .078 | .058 | .026 |

[a] 10 percent higher than the average.

[b] The average for the entering cohort.

[c] 10 percent lower than the average.

Table 42

COMPARISON OF RETENTION EFFECTS BY DIFFERENT CIVILIAN INCOME OPPORTUNITIES, POLICY 2, DISCOUNT RATE 10 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Civilian Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| High[a] | | | | | | | | |
| Retention rate (current) | .252 | .367 | .741 | .918 | .732 | .468 | .303 | .175 |
| Effect of Policy 2 | -.001 | -.007 | -.027 | -.043 | .049 | .078 | .077 | .002 |
| Average[b] | | | | | | | | |
| Retention rate (current) | .326 | .528 | .798 | .947 | .717 | .527 | .366 | .194 |
| Effect of Policy 2 | -.003 | -.014 | -.024 | -.015 | .064 | .078 | .043 | .021 |
| Low[c] | | | | | | | | |
| Retention rate (current) | .416 | .665 | .870 | .960 | .768 | .573 | .394 | .207 |
| Effect of Policy 2 | -.004 | -.018 | -.016 | -.008 | .055 | .069 | .021 | .045 |

[a] 10 percent higher than the average.

[b] The average for the entering cohort.

[c] 10 percent lower than the average.

## Differential Effects by Promotion Probabilities

Table 43 shows that those with higher promotion probabilities stay more often than those with lower promotion probabilities for reasons that are similar to the ones pertaining to civilian opportunities. Furthermore, individuals with different promotion probabilities are affected differentially when policies change. At the first decision point, the retention rate of those with higher promotion probabilities is closer to the 50th percentile (the mode of the taste distribution is assumed to be normal). Therefore, the retention rate is reduced by the largest amount at YOS 4 for those with high promotion probabilities. After the first decision point, selection effects also come into play.

Individuals with high promotion probabilities may also have high civilian income opportunities. The simulations assumed that 75 percent of those with high promotion probabilities also have high civilian income opportunities and the rest have normal civilian income opportunities. Similarly, 75 percent of those with low promotion probabilities are assumed to have low civilian opportunities. But Table 43 compares groups with average civilian income opportunities who differ *only* in their promotion probabilities. Those with high promotion probabilities may also have higher tastes for the military. But that is not modeled in the simulations because the estimation (or the calibration) of the DRM is already difficult, and including another parameter would have complicated the process even further. Also, measurement of the inherent differences among individuals in terms of their promotion opportunities is not an easy task.

## Differential Effects by Bonus Opportunities

Table 44 shows the retention rates and the differential effects of changing the retirement system to Policy 2 by bonuses that are offered. First, during the first two terms, those who are in bonus specialties stay more often than those who are not offered any bonuses. Second, following the bonuses, those who were in bonus specialties leave at a higher rate than others because individuals who were induced to stay with the bonuses have, on the average, lower tastes for the military than those who stayed without the inducement of bonuses. Finally, the differential effects of retirement policy changes by bonus group are not

Table 43

COMPARISON OF RETENTION EFFECTS BY DIFFERENT PROMOTION OPPORTUNITIES, POLICY 2, DISCOUNT RATE 5 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Promotion Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| High[a] | | | | | | | | |
| Retention rate (current) | .324 | .529 | .851 | .977 | .741 | .459 | .290 | .186 |
| Effect of Policy 2 | -.014 | -.053 | -.045 | -.012 | .070 | .107 | .054 | .032 |
| Average[b] | | | | | | | | |
| Retention rate (current) | .318 | .502 | .829 | .968 | .685 | .458 | .298 | .146 |
| Effect of Policy 2 | -.014 | -.055 | -.052 | -.019 | .075 | .098 | .053 | .032 |
| Low[c] | | | | | | | | |
| Retention rate (current) | .301 | .462 | .821 | .964 | .631 | .449 | .242 | .127 |
| Effect of Policy 2 | -.013 | -.052 | -.070 | -.021 | .071 | .068 | .054 | .086 |

[a] 10 percent higher than the average.

[b] The average for the entering cohort.

[c] 10 percent lower than the average.

Table 44

COMPARISON OF RETENTION EFFECTS BY DIFFERENT BONUS OPPORTUNITIES,
POLICY 2, DISCOUNT RATE 5 PERCENT
(1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Bonus | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| None | | | | | | | | |
| Retention rate (current) | .303 | .524 | .856 | .973 | .701 | .480 | .298 | .135 |
| Effect of Policy 2 | -.014 | -.055 | -.042 | -.018 | .069 | .086 | .042 | .027 |
| Offered Only at YOS 8[a] | | | | | | | | |
| Retention rate (current) | .319 | .567 | .857 | .969 | .695 | .477 | .257 | .142 |
| Effect of Policy 2 | -.015 | -.048 | -.046 | -.016 | .083 | .102 | .037 | .009 |
| Offered Only at YOS 4[b] | | | | | | | | |
| Retention rate (current) | .339 | .512 | .851 | .969 | .711 | .481 | .307 | .102 |
| Effect of Policy 2 | -.013 | -.049 | -.044 | -.016 | .073 | .085 | .054 | .044 |
| Offered at YOS 4 and 8[c] | | | | | | | | |
| Retention rate (current) | .358 | .558 | .848 | .969 | .711 | .459 | .303 | .176 |
| Effect of Policy 2 | -.014 | -.050 | -.046 | -.015 | .067 | .093 | .057 | .038 |

[a] A bonus multiple of 1.2 is offered at YOS 8.

[b] A bonus multiple of 1.2 is offered at YOS 4.

[c] A bonus multiple of 1.2 is offered at both YOS 4 and YOS 8.

large because bonuses are paid only once. They do not influence individual behavior as much as the inherent differences among individuals in their opportunities that presumably persist over their lifetimes. Table 44 shows the effects of bonuses holding all other factors constant. Actually, bonuses are more likely to be offered to those specialties that command higher wages in the civilian sector. Therefore, there may be an interaction between civilian opportunities and bonuses, but to keep the simulation model manageable, such interactions were not modeled. A modification to include such interactions could be used for the analysis of special pays.[15]

Comparison of Table 44 with Table 45 shows that retention rates among groups that have different bonus opportunities but the same civilian and promotion opportunities do not vary significantly under different discount rate assumptions. The payment of bonuses is not too far in the future at any of the decision points, and bonuses are one time payments.

## SUMMARY

Analysis of retirement policies should give consideration to both the costs and the military readiness effects. Evaluation of the effects on military readiness is much more difficult. The retention models could be used in two ways: first to provide inputs to cost-benefit analyses by predicting the retention effects of different retirement systems and second to search for compensation packages that can produce the same force profiles thereby side-stepping the difficult issue of assessing military readiness effects.

The ability of the retention models to provide information on retention rates disaggregated by YOS, grade, occupational group, and quality levels is important for three reasons. First, such disaggregation enables better assessment of the cost and military readiness effects. Second, it may provide more accurate assessment of the retention effects of various policies. Third, it provides a means of evaluating the equity aspects of different policies.

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[15]If such modifications are made the term of enlistment effect of the bonuses also should be captured. See Carter (1985) and Hosek and Peterson (1985).

Table 45

COMPARISON OF RETENTION EFFECTS BY DIFFERENT BONUS OPPORTUNITIES, POLICY 2, DISCOUNT RATE 10 PERCENT (1% PERMANENT PENALTY ON MULTIPLIER FOR EARLY RETIREMENT)

| Bonus | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| None | | | | | | | | |
| Retention rate (current) | .304 | .533 | .821 | .952 | .729 | .540 | .350 | .194 |
| Effect of Policy 2 | -.003 | -.014 | -.022 | -.012 | .064 | .071 | .048 | .029 |
| Offered Only at YOS 8[a] | | | | | | | | |
| Retention rate (current) | .315 | .584 | .814 | .948 | .722 | .537 | .330 | .170 |
| Effect of Policy 2 | -.003 | -.013 | -.021 | -.011 | .056 | .072 | .031 | .026 |
| Offered Only at YOS 4[b] | | | | | | | | |
| Retention rate (current) | .342 | .512 | .800 | .948 | .719 | .538 | .359 | .183 |
| Effect of Policy 2 | -.002 | -.016 | -.026 | -.019 | .065 | .073 | .039 | .027 |
| Offered at YOS 4 and 8[c] | | | | | | | | |
| Retention rate (current) | .357 | .553 | .794 | .949 | .729 | .512 | .362 | .197 |
| Effect of Policy 2 | -.002 | -.017 | -.024 | -.016 | .060 | .072 | .045 | .028 |

[a] A bonus multiple of 1.2 is offered at YOS 8.

[b] A bonus multiple of 1.2 is offered at YOS 4.

[c] A bonus multiple of 1.2 is offered at both YOS 4 and YOS 8.

Years of service is the most important dimension of a force profile because the retention rates, costs, and possibly the readiness effects are most heavily influenced by it. In terms of the inputs, the discount rate assumptions seem to have the greatest influence on the predicted retention rate effects because the smaller the discount rate, the larger is the weight given to the retirement benefits in the total compensation package.

Two factors play a role in increasing the accuracy of retention rate predictions. First, when separate groups of personnel with different retention rates could be identified, the observed retention rates of similar personnel who have been through a particular decision point provide information about the attractiveness of military life (with its compensation level and other nonpecuniary benefits) to similar personnel. If military life is very attractive or very unattractive, small changes in the compensation levels are unlikely to have major effects on retention rates. Second, past retention rates of a particular group of personnel give us information about those who have chosen to stay until now. In particular, if very few personnel stayed from a given cohort, then those who did stay would have done so despite unattractive (as seen by individuals who started out at the same cohort) military compensation levels. Therefore, those who stayed are unlikely to change their decisions with small changes in compensation levels. This analysis indicates that even a 10 percent persistent difference in civilian income or promotion opportunities could lead to major differences in the retention rates of different groups of personnel.

# VII. CONCLUSIONS AND POLICY IMPLICATIONS

- Are the available retention models good enough for analyzing the effects of military retirement policies on force profiles?
- Which input assumptions influence the predictions of these models most?
- How can these models and their inputs be improved?
- What are the most promising avenues of future research on the modeling of retention behavior?
- What are the implications for retirement policy analysis and policy analysis in general?

This section will attempt to answer these questions by pulling together the results from previous sections.

## RETENTION MODELS

Four basic retention models were analyzed: (1) the present value of cost of leaving (PVCOL) model, (2) the perceived pay model (PPM), (3) the annualized cost of leaving (ACOL) model, and (4) the dynamic retention model (DRM). Particular emphasis was placed on the ACOL model and the DRM.

The DRM is the theoretically most rigorous and internally consistent model in its treatment of the four major determinants of retention behavior: military income opportunities, civilian income opportunities, persistent individual differences in evaluating the nonpecuniary factors associated with military life (tastes), and random events such as a sickness in the family. However, estimating the parameters of the DRM is difficult, especially for enlisted personnel for whom more disaggregation of the retention effects may be required.[1] Also, adding other variables that may affect individuals' retention decisions (such as

[1] Gotz and McCall (1984) disaggregate Air Force officers into three groups in estimating the DRM.

civilian unemployment rates) will further increase the DRM's complexity and difficulty of its estimation.

The most commonly used retention model in retirement policy analysis, the ACOL model, has three major limitations. First, although it incorporates tastes, it does not censor them as a cohort ages. It pools data from different years of service in the estimation of the model, which causes overpredicting of the retention effects of retirement policies. Second, it does not explicitly model the effect of random shocks on retention decisions, which causes underpredicting of the effects of changes in the retirement system. The magnitudes of these biases depend on the additional variables used in the ACOL model. The specification that was used by QRMC V indicates that the net result of these two limitations is to underpredict the retention effects, particularly in the earlier YOS when more individuals are affected. Therefore, the ACOL model's predictions of changes in the retirement system are not conservative. Furthermore, the biases are so significant that, for policies that are similar to the ones analyzed by the QRMC V,[2] the ACOL model captures only one-quarter to one-third of the changes in the retention rates at YOS 8 and 12. Because most airmen who stay past YOS 12 remain in military service until YOS 20, underprediction of the effects of policy changes in these years of service are very important in terms of the manyears affected. Third, the ACOL model predicts no changes in retention rates for policies that affect the benefits at any future decision point except the best one, where the best future decision point is the YOS that maximizes an individual's returns from staying in the military if he stays in the military until that YOS and then leaves. In short, ACOL is a maximum regret model.

One way to deal with the *first* difficulty of the ACOL model is to include a proxy variable to measure the effect of censoring tastes. Using a function of the proportion of an entering cohort still in the military to make a stay/leave decision at a particular decision point as the proxy variable significantly improved ACOL's predictions.[3]

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[2]For example, changing the multiplier to 2.0 percentage points for the first 20 YOS and 3.5 percentage points for each year thereafter until YOS 30.

[3]The proxy was the mean of the truncated normal distribution, where the truncation level is the point that makes the proportion of the

A simple way to deal with the *second* limitation is to include YOS dummies in the regression equation. But YOS and the censoring of tastes are strongly correlated, so the censoring effect becomes more difficult to estimate within this specification. Because YOS dummy variables capture both censoring of tastes and random shocks effects, this model performs reasonably well when the policies analyzed are not major departures from the current one (so the censoring effects would not change much from the estimated effects). As more variables that reduce the random shock variances (such as civilian unemployment rates) are included in the ACOL model, the biases caused by the second limitation will be reduced. A promising avenue for future research to deal with both of these limitations would be to estimate a variance components model with the taste proxy and the ACOL measure as the independent variables.

To deal with the *third* limitation a weighted average was used of the ACOL values for leaving at each future decision point rather than focusing on the best one. But it was not possible to identify a satisfactory weighting scheme because a proper weighting scheme depends on tastes. If the observed retention rates are used in the weighting scheme without incorporating tastes, the weights may reflect weights placed on future decision points by those who stay, but cannot reflect the true weights for those who leave. Therefore, such weights will introduce biases. But incorporating tastes into the weights would complicate the ACOL model so much that it would not have any advantage over the DRM in terms of ease of estimation. In practice, the third limitation is not as important as the first two because most retirement policies do not affect the second-best time horizon differently from the best time horizon.

The inherent problem with weighting schemes that do not incorporate tastes is also one of the major limitations of the PPM. PVCOL's major limitations are not modeling tastes at all, being a maximum regret model, and incorporating random shocks only in the error term, implying

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cohort still with the military equal to the area under the normal probability density function to the right of the truncation point. This proxy also captures some of the interaction between tastes and random shocks.

that individuals receive a random shock at each period but keep behaving as if the current random shock is the last one they will receive. Both the PPM and the PVCOL model seem to overpredict retention effects.

Evaluation of the adequacy of the simpler models for retirement policy analysis is based on a simulation methodology. This methodology used a theoretically sound model, the DRM, to generate pseudo-data under different policy settings.[4] Then the simpler models' predictions were evaluated against simulated retention behavior. Just as military capability cannot be fully tested without going to war, the retention models cannot be fully tested without actually changing the retirement system. But just as using war games can give us an idea about military capability, simulation is useful in evaluating the adequacy of the simpler models.

Simulation methodology can be used to enhance the understanding of the retention models and the implicit assumptions that are made in the estimation stage. For example, the effectiveness of further modifications to the ACOL methodology could be tested. Also, the biases caused by other types of misestimation of the inputs could be analyzed. For example, if the civilian income opportunities are suspected to be misestimated according to patterns other than the ones in Sec. V, the effects of such misestimation could be studied. Finally, the magnitude of other potential problems could be determined. For example, the effects of using only cross-sectional data could be analyzed by creating the simulated database using longitudinally varying inputs and then estimating the retention models using only cross-sectional data.

In summary, the crude calibration of the DRM can be used to analyze the *general* pattern of the retention effects of various retirement policies.[5] A formal estimation for more accurate predictions is likely to be too difficult, especially when separate effects for different

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[4]The simulations under the current retirement policy mimic the actual retention rates.

[5]The conformity between this calibration methodology and a rigorous estimation of the DRM has not been tested. But the calibrated model tracks the observed retention rates in 1971-1981 well, the elasticities of retention rates to uniform increase in the military pay schedule is in accord with previous studies, and the predictions of the model are plausible.

occupational groups are desired. Other retention models could have very large biases in analyzing retirement policies. However, the ACOL model can be greatly improved by minor modifications. It may even be improved further by estimating a variance components model. In any case, the disaggregation of the effects of retirement policies may have to be estimated by the ACOL model because of the ease of its estimation compared with the DRM. The simulation methodology developed in this research can be used (1) to identify and test the adequacy of improvements to the ACOL methodology, (2) to quantify and correct for the biases caused by the input assumptions, (3) to quantify and correct for the biases in the ACOL methodology when specific retirement policies are analyzed,[6] and (4) to identify policies that the ACOL methodology cannot analyze.

## INPUTS FOR THE RETENTION MODELS

Many input assumptions are made in estimating retention models. This study particularly emphasized the implicit discount rate, civilian income opportunities, and promotion opportunities. The implicit discount rate has a major effect on how individuals value deferred benefits. The lower the discount rate, the larger the value of future benefits and therefore the greater the retention effects of retirement plans that change the value of future benefits. The discount rate used should be empirically based because it is a behavioral concept. However, its estimation is difficult. Difficulty in estimating the implicit discount rates is similar to the difficulty in evaluating the performance of different retention models. They both originate from not having sufficient variance in the deferred compensation component of military compensation in the past decade. The sensitivity of the results to different discount rate assumptions was analyzed and it was found that accurate estimation of implicit discount rates is very

[6]The extent of the biases in the ACOL methodology is policy dependent. Therefore, using the simulation methodology to quantify the biases for a given policy could give valuable insights to the users of the ACOL.

The analysis also indicated that assumptions about the civilian income opportunities of military personnel influence the estimates of retention effects. Until recently, work on civilian earnings opportunities of military veterans suffered from inadequate data. But the Defense Manpower Data Center (DMDC), the Internal Revenue Service (IRS), and the Social Security Administration (SSA) constructed a comprehensive database for QRMC V. It is expected to be updated annually. Therefore, the major remaining problem in this area is to resolve the issue of estimating the civilian earnings opportunities of *all* military personnel by observing *only* the opportunities of those who choose to leave the military. Applying advanced statistical techniques to correct for the selection biases (that those who receive very high offers are more likely to leave the military than others) should improve the estimates. Because civilian income opportunities are important in military personnel's evaluation of military compensation, such work would improve analysis of the retention effects of retirement policies.

Estimates of promotion probabilities faced by military personnel also have an influence on predictions about retention effects of retirement policies. Ward and Tan (1984) provide a very good framework. Further work in this area could improve the predictions of retention models. However, accurate estimates of discount rates and civilian income opportunities seem to be more important than accurate estimates of promotion probabilities for analysis of retirement policies.

In summary, sensitivity analyses indicate that the input assumptions made in retention modeling are as important as the models. Therefore, input preparation should receive as much analytical attention as the models themselves. The most important inputs in retirement policy analysis are, in order of importance, the discount rate, civilian income opportunities, and promotion probabilities.
important in predicting retention effects of retirement policies.[7] Therefore, more work in this area is likely to be very valuable.

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[7]Section III provides theoretical justification for using a discount rate that varies with YOS and Secs. V and VI show that the estimation of aggregate and disaggregate effects of policy changes are heavily influenced by the discount rate assumptions.

## POLICY ANALYSIS

In the current retirement system, the size of the retirement annuity provides a major retention incentive, especially during YOS 10 to 20. Although only about 11 percent of an entering cohort of enlisted personnel stay until retirement eligibility, more than 80 percent of those who serve 12 years stay until YOS 20. Then, about 45 percent of the enlistees retire within the first year of retirement eligibility. Therefore, any major change in the current retirement system will have considerable retention effects with associated cost and military readiness effects.

There has been little variation in the deferred compensation component of the military compensation package, making estimation of the potential effects of changes in the retirement policies difficult. Therefore, theoretical rigor and internal consistency of the retention models, which are less important in other applications, become very important in retirement policy analysis. The most commonly used retention model, the ACOL model, could lead to seriously biased estimates of the retention effects of retirement policies. Policy recommendations of studies based on the ACOL methodology are influenced by its limitations.

One of the recommendations of QRMC V demonstrates this point: Reduce the multiplier for early retirees but keep it the same for those who complete a full career of 30 years and at the same time provide a cash payment, called early withdrawal (EW), at the end of 20 YOS or more. The cash payment is determined such that the approximate force profile would be similar to the current force profile. QRMC V used the ACOL methodology to analyze the effects of this change on force profiles and to determine the amount of EW that would keep the retention rates similar to current retention rates. Recall that the ACOL model greatly underestimates the retention effects of a policy change that reduces the multiplier for early retirees, both the reduction in retention rates before YOS 20 and the increase in retention rates after YOS 20 (see Sec. IV). If the EW amount was determined correctly to keep the retention rates before YOS 20 similar to the current retention rates, the change in the retention rates for the 20-30 YOS period will be about twice as large as the changes the ACOL model predicts.[8] To be able to keep the retention rates before YOS 20 similar to the current retention rates, the EW amount would be such that the value of the retirement benefits at YOS 20 under the proposed system would be similar to the value of the benefits under the current system. The ACOL model underpredicts the reduction in the retention rates before YOS 20 due to the reduced multiplier policy, but it also underpredicts the increase in the retention rates due to the EW amount. Hence the ACOL model may determine the EW amount correctly. But under the proposed policy, each year of service after YOS 20 would increase the multiplier by more than the current 2.5 percentage points per year. Because the ACOL model underestimates the retention effects of this incentive in YOS 20-30, this proposal may not provide the suggested cost savings. That is, more individuals would stay in the military for longer periods of time to earn higher retirement benefits.

The EW amount may be reduced in the policy arena either when the suggested cost savings are not realized or for political reasons. But the reduction in the retention rates before YOS 20 would be three to four times as large as the ACOL model predicts, possibly leading to unacceptable readiness effects. QRMC V analyzed the sensitivity of the results to the discount rate assumptions by using the ACOL methodology. But those sensitivity analyses provide only lower limits on the actual sensitivities to the discount rates, because the ACOL model underpredicts the retention effects under all discount rate assumptions.

The ACOL methodology should be improved before it is used for retirement policy analysis. Section IV provides some simple modifications that can greatly improve the ACOL model's predictions. Simulation methodology based on a theoretically consistent model, the DRM, provides a test bed to analyze these improvements.

The ability of the retention models to provide information on retention rates disaggregated by YOS, grade, occupational group, and quality levels is important for three reasons. First, such

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[8]The magnitude of the underestimation depends on the discount rate assumptions. Also there are other more subtle effects of this policy change. For a more detailed description of these effects of the reduced multiplier for early retirees, see Secs. IV and VI.

disaggregation enables better assessment of cost and military readiness effects. Second, it may provide more accurate assessment of the retention effects of different policies. Third, it provides a means of evaluating the equity aspects of various policies. The assessment of cost and military readiness will be improved because personnel with different experience and quality levels cost the military different amounts and have different contributions to readiness. The accuracy of retention predictions could be improved because the fact that an individual stays despite unfavorable financial incentives indicates that he values the nonpecuniary factors of military life very highly. Being able to identify individuals who have faced various financial incentives provides information about differences in their evaluations of nonpecuniary factors. Finally, the effects of a policy change are not necessarily the same for each individual, and the equity aspects of policy changes can be analyzed only if differential effects by separate groups of personnel are known. This need for disaggregation is one of the reasons for trying to utilize the simpler models in retirement policy analysis.

The general lessons that can be drawn from this research are: (1) explicitly laying out the assumptions of the theoretical model and the estimation procedure is essential in understanding and using econometric models, and in ensuring internal consistency; (2) not doing so can lead to significant prediction errors; (3) a theoretically superior model is not necessarily the best one to use for policy analysis because estimation of its parameters can be very difficult, and simpler models may be able to approximate the complex models (and the real world) closely enough for analysis of many policies; (4) a theoretically rigorous and consistent view of the world is essential in understanding the limitations and applicability of different approximations to reality (models).

In 1976, Robert Lucas of the University of Chicago started the "rational expectations" revolution in macroeconomics. This theory suggests that when a policy intervention changes the structure of the econometric models that are estimated, those models cannot be used for analyzing that policy. Use of econometric models in policy analysis requires development of models that will not be affected by the policies that they are intended to analyze. Concerns in this work have been very similar in spirit to the rational expectations theory, which is why the DRM is endorsed on theoretical grounds. However, in practice, empirical implementation of such models may be very difficult.

Nevertheless, having a theoretical structure that supports policy analysis is important. In developing a simulation methodology, a "theoretically correct" model has been used to generate pseudo-data that in turn were used in evaluating simpler models. This type of approach has been used in statistics in evaluating the properties of different estimators. It has been applied in a policy setting to evaluate the adequacy of simpler models for policy analysis by Ignall, Kolesar, and Walker (1978). The best way to evaluate the adequacy of a model for policy analysis is to compare the model's predictions with what actually happens. But to be able to apply this test one would have to wait for the implementation of the policy, which means the model would no longer be needed to make predictions about this particular policy. Short of changing the policies to evaluate models, the simulation approach may be the only way to evaluate the practical importance of the "Lucas critique" for simpler models under different policy settings.

# Appendix A

## MATHEMATICAL FORMULATION OF BEHAVIORAL MODELS OF RETENTION

This appendix explains the mathematical formulation of the behavioral retention models that were explained in Sec. II. First, the variables that are common to all the models are defined, followed by a description of the models and some of their theoretical limitations. Finally, the effect of random shocks on the retention rate at the first decision point will be demonstrated.

### VARIABLE DEFINITIONS

Let

$i$ = years of service.
$g$ = grade.
$j$ = number of years from YOS 1 to expected cash flow.
$a$ = age, which is assumed to be $j+19$, unless otherwise stated.
$ri$ = the retention rate at YOS i.

$P(x|y)$ = the probability of event x occurring given state y, for any x and y.

$cpay_{i,j,t}$ = expected civilian pay at period t for an individual who leaves military service with YOS i and who entered military service j years ago.

$mpay_{i,g,t}$ = expected active duty military pay at period t for an individual who is in grade g and has YOS i.

$spay_{i,g,t}$ = expected severance pay associated with involuntary separation at period t for an individual who is in grade g, has YOS i.

$rpay_{i,g,j,t}$ = expected retirement pay at period t for an individual who retires at YOS i with grade g and who entered military service j years ago.

$P(g|i)$ = the probability of being in grade g at YOS i.

$surv_a$ = the probability of an individual surviving for an additional year if his age is a.

$$\beta_{i,j} = \prod_{n=1}^{j} \{1/(1 + d_{n+19})\} \cdot surv_{n+19}$$

where $d_{n+19}$ is the individual's age-specific rate of time preference, or implicit discount rate.

In this appendix the index, t, which indicates fiscal years, will be dropped for expositional clarity.[1]

## BEHAVIORAL MODELS OF RETENTION

### The PVCOL Model

PVCOL assumes individuals know their potential future military and civilian income streams with certainty, or they know the expected value of such income streams and are risk neutral. Consider an individual who is at the end of YOS i, facing a stay/leave decision. His return from leaving is

$$L_i = \sum_{j=i+1}^{\infty} (cpay_{i,j} + rpay_{i,gg(i)}) \cdot \beta_{i,j} \ , \qquad (A.1)$$

where gg(i) is the grade at YOS i, which maximizes P(g|i). There are only nine possible grades.

His return from staying is dependent on when he finally decides to leave, and equal to

$$S_{i,k} = \left\{ \sum_{n=i+1}^{k} mpay_{n,gg(n)} \cdot \beta_{i,n} \right\} + L_k \cdot \beta_{i,k} \ , \qquad (A.2)$$

where gg(n) is the grade at YOS n that maximizes P(g|n). The present value of cost of leaving at YOS i for an individual who would stay until YOS k is calculated as

$$PVCOL_{i,k} = S_{i,k} - L_i \ . \qquad (A.3)$$

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[1]If time independence of real income streams is assumed, t would not be required.

PVCOL's cost of leaving is a maximum regret measure.

$$PVCOL_i = \max_k(S_{i,k}) - L_i = \max_k(PVCOL_{i,k}) \ .$$

Note that a backward recursive formulation technique would reduce the computational requirements (starting to solve for $PVCOL_i$ from the largest value of i and working toward smaller values of i).

According to this model, an individual who faces $PVCOL_i$ at YOS i will remain in the military if $(PVCOL_i + \varepsilon_{n,i}) > 0$, where the random disturbance $\varepsilon_{n,i}$ (for the nth individual at the ith year of service) is identically, independently, logistically distributed with mean $\mu$ and standard deviation $1.8137\zeta$. Therefore, the retention probability is $r_i = \{1 + \exp[(PVCOL_i - \mu)/\zeta]\}^{-1}$. Hence, by relating $r_i$ to $PVCOL_i$ through

$$r_i = \{1 + \exp[-(\alpha_0 + \alpha_1 \cdot PVCOL_i)]\}^{-1} \ , \tag{A.4}$$

inferences can be made about the parameters of the probability distribution of random disturbances by estimating $\alpha_0$ and $\alpha_1$ by maximum likelihood.

Note that $\dfrac{dPVCOL_i}{dmpay_{i,gg(i)}} = 0$

where gg(i) is any grade at YOS i that does *not* maximize P(g|i).

Therefore, $$\frac{dr_i}{dmpay_{i,gg(i)}} = \frac{dr_i}{dPVCOL_i} \cdot \frac{dPVCOL_i}{dmpay_{i,gg(i)}} = \alpha_1 r_i(1 - r_i) \cdot 0 = 0$$

Similarly, $$\frac{dPVCOL_i}{dS_{i,k}} = 0$$

as long as $$\frac{d\max_k(S_{i,k})}{dS_{i,k}} = 0(5) \tag{A.5}$$

Hence, $\dfrac{dr_i}{dS_{i,k}} = 0$, whenever condition (5) holds.

Also note that because there is no variable accounting for the increase in taste with years of service (the selection effect), the estimate of $\alpha_1$, $\hat{\alpha}_1$, will suffer omitted variables bias. Furthermore, $PVCOL_i$ and the omitted variable are positively correlated and $\alpha_1$ is positive. Hence, $\alpha_1 - \hat{\alpha}_1 > 0$. That is, the bias will be positive,[2] thereby leading to overprediction of the effects of changes in $PVCOL_i$.

## The Perceived Pay Model

PPM assumes individuals know their potential future military and civilian income streams with certainty, or they know the expected value of such income streams and are risk neutral. Consider an individual who is at the end of YOS i, facing a stay/leave decision. His return from leaving is

$$L_i = \sum_{j=i+1}^{\infty} (6)(cpay_{i,j} + rpay_{i,j}) \cdot \beta_{i,j} \ ,$$

$$\text{where} \qquad rpay_{i,j} = \sum_{g=1}^{9} P(g|i) \cdot rpay_{i,g,j} \ . \qquad \text{(A.6)}$$

His return from staying is dependent on when he finally decides to leave, and equal to

$$S_{i,k} = \left\{ \sum_{n=i+1}^{k} mpay_n \cdot \beta_{i,n} \right\} + L_k \cdot \beta_{i,k} \ ,$$

$$\text{where} \qquad mpay_n = \sum_{g=1}^{9} P(g|n) \cdot mpay_{n,g} \ . \qquad \text{(A.7)}$$

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[2]For a derivation of the omitted variables bias in ordinary least squares estimation, see Kmenta (1971, pp. 392-395). For the logistic regression case, the derivation will not be materially different.

Perceived pay is defined as

$$\mathrm{PPAY}_i = \left\{ \sum_{k=i+1}^{30} \left( \prod_{m=1}^{k-1} r_m \right) (1 - r_k) \cdot S_{i,k} \right\} / L_i \ . \tag{A.8}$$

Note that $PPAY_i$ is a unitless measure.

The proportion of the cohort who left military service until the current decision point is used as a proxy for taste.

$$\mathrm{TPRXY}_i = 1 - \prod_{k=1}^{i-1} r_k$$

According to this model, the error term is assumed to follow a logistic distribution. Therefore, $PPAY_i$ and $TPRXY_i$ are related to $r_i$ through a logistic supply function.

$$r_i = \{1 + \exp[-(\alpha_0 + \alpha_1 \mathrm{PPAY}_i + \alpha_2 \mathrm{TPRXY}_i)]\}^{-1} \tag{A.9}$$

Note that $TPRXY_i$ requires continuation probabilities before YOS i. However, $PPAY_i$ is a function of $r_j$, where $j > i$. Therefore, the model works iteratively for making predictions. In the first iteration, current retention rates are used in calculating $TPRXY_i$; the second iteration uses the rates predicted in the first iteration. This process continues until predictions from successive iterations converge.

Because predicted retention rates, $r_i$, are conditional probabilities of staying with the military (conditional on having stayed until the current decision point), they are likely to be higher than the probability of staying for those who actually leave at the earlier decision points. Therefore, the perceived pay will overrepresent the far future pays, and predictions of retention effects at the early decision points due to changes in the retirement system are likely to be too high. Also, Eq. (A.9) does not have an interaction effect between $PPAY_i$ and $TPRXY_i$. Therefore, if the responses of individuals to $PPAY_i$ are different depending on their tastes, which is likely, then the predictions of this model will be biased for years of service where average tastes are different from the mean tastes over the whole force.

## The ACOL Model

The ACOL model also assumes that individuals know their potential future military and civilian income streams with certainty, or they know the expected value of such income streams and are risk neutral. However, the ACOL recognizes that individuals persistently differ in their tastes toward military life.

Let $\gamma_p$ be the monetary equivalent of the annual nonpecuniary returns associated with military life (net of those in civilian life) for the nth individual. Therefore, it is represented in the returns to staying equation, and the returns to leaving are calculated as in the PVCOL model. The return from leaving is equal to

$$L_i = \sum_{j=i+1}^{\infty} (cpay_{i,j} + rpay_{i,gg(i)}) \cdot \beta_{i,j} \ , \qquad (A.10)$$

where gg(i) is the grade at YOS i that maximizes P(g|i). Returns from staying are dependent on when an individual finally decides to leave, and equal to

$$S_{n,i,k} = \left\{ \sum_{n=i+1}^{k} \left( mpay_{n,gg(n)} + \gamma_p \right) \cdot \beta_{i,1} \right\} + L_k \cdot \beta_{i,k} \ , \qquad (A.11)$$

where gg(n) is the grade at YOS n that maximizes P(g|n).

Cost of leaving for the pth individual, at the ith YOS, is conditional on staying until YOS k,

$$COL_{i,k}(\gamma_p) = S_{n,i,k} - L_i \ . \qquad (A.12)$$

For the time being, ignore the issue of which of the future decision points is the best to leave and drop index k. Then the retention rate, $r_i$, is the proportion of individuals for whom $COL_i(\gamma_n) > 0$. If the distribution of tastes among the individuals who face a stay/leave decision is $f_i(\gamma)$ and $\gamma^*$ is defined as $COL_i(\gamma^*) = 0$ , then the distribution of tastes among the individuals who face a stay/leave decision is $f_i(\gamma)$ and $\gamma^*$ is defined as $COL_i(\gamma^*) = 0$ , then

$$r_i = \int_{-\gamma_i}^{\infty} f(\gamma)d\gamma \ . \tag{A.13}$$

$ACOL_i$ is defined as $\gamma_i$. Introducing k back to the cost of leaving measure,

$$ACOL_{i,k} = \frac{\left\{\sum_{n=i+1}^{k} (mpay_{n,gg(n)} \cdot \beta_{i,n}\right\} + L_k \cdot \beta_{i,k} - L_i}{\sum_{n=i+1}^{k} \beta_{i,n}} \ .$$

Note that

$$ACOL_{i,k} = \frac{PVCOL_{i,k}}{\sum_{n=i+1}^{k} \beta_{i,n}} \ . \tag{A.14}$$

This model assumes that an individual will stay with the military if there is at least one future time horizon over which his taste factor $\gamma_n > \gamma^*$. Therefore, the time horizon to look at in calculating the returns to staying is resolved by choosing the time horizon that maximizes $\gamma^*$. $ACOL_i$ is defined as

$$ACOL_i = \max_k(ACOL_{i,k}) \ . \tag{A.15}$$

The k that maximizes $PVCOL_{i,k}$ is not necessarily the same as the k that maximizes $ACOL_{i,k}$. Tastes are assumed to be distributed according to a logistic distribution function, and the parameters of the taste distribution are estimated using the following equation:

$$r_i = \{1 + \exp[-(\alpha_0 + \alpha_1 ACOL_i)]\}^{-1} \ . \tag{A.16}$$

This statistical methodology implicitly assumes that tastes are identically independently and logistically distributed over time and across individuals, introducing a logical inconsistency into the model because tastes were assumed to be persistent over time in the calculation of $ACOL_i$. If tastes are assumed to be fixed, then this inconsistency can be eliminated. But at the second decision point, the distribution of tastes will be a truncated distribution, and whenever $ACOL_1 < ACOL_2$ (which is usually the case because of the retirement system), the model will predict $r_2$ to be equal to one (contrary to what is observed).

To model the effect of an increasing mean of the taste distribution over years of service, ad hoc fixes like adding a YOS variable to Eq. (A.16) have been used in applications.

$$r_i = \{1 + \exp[-(\alpha_0 + \alpha_1 ACOL_i + \alpha_2 g(YOS))]\}^{-1} , \tag{A.17}$$

where g(YOS) is any function of YOS, such as log(YOS). But the estimate of $\alpha_2$, $\hat{\alpha}_2$, will be based on the pattern of censoring at the time of the data that were used for estimation, and the model will not be able to respond to major changes in the pattern of censoring because of large compensation policy changes. ACOL, like PVCOL, is a maximum regret model, so it will not be able to respond to some policy changes.

Note that $$\frac{dACOL_i}{dmpay_{i,gg(i)}} = 0$$

where gg(i) is any grade at YOS i that does *not* maximize $P(g|i)$.

Therefore, $$\frac{dr_i}{dmpay_{i,gg(i)}} = \frac{dr_i}{dACOL_i} \cdot \frac{dACOL_i}{dmpay_{i,gg(i)}} = \alpha_1 r_i(1 - r_i) \cdot 0 = 0 .$$

Similarly, $$\frac{dACOL_i}{dS_{i,k}} = 0 ,$$

as long as $$\frac{d\max_k(ACOL_{i,k})}{dS_{i,k}} = 0 \ . \tag{A.18}$$

Hence, $\frac{dr_i}{dS_{i,k}} = 0$, whenever condition (A.18) holds.

### The Dynamic Retention Model

The DRM assumes that individuals know their potential future civilian income stream and the military pay schedule they will face with certainty (or they know the expected value of such income streams and are risk neutral). Individuals do not know either the actual grades they will achieve or the actual military pay they will receive, but they know the transition probabilities they face in moving from one state to another, where the states are defined as the years of service, grade, and promotion timing combinations. The transition probabilities, $P_{s_i,s_k}$ are assumed to follow a first order Markov process, where $s_i$ is the current state at YOS i and $s_k$ is the future state at YOS k. $P_{s_i,s_k}$ are conditional on not leaving the military voluntarily. The high year of tenure (HYT) policies are also reflected in this first order Markovian matrix by assuming one of the states is civilian employment. $P_{s_i,s_k} = 0$ whenever $s_i > s_k$, thereby implying that there are no demotions.

The DRM explicitly recognizes that there are two types of nonpecuniary returns: (1) tastes, which persist over time and whose values are known to the individuals; and (2) random shocks, which are identically, independently distributed over time, and individuals know about the current value of the random shocks and their probability distribution function. Let $\gamma_p$ be the monetary equivalent of the annual taste factor (net of those in civilian life) for the nth individual. Tastes, $\gamma$, are assumed to be distributed according to a cumulative distribution function H in the entering cohort.[3] Let $\varepsilon_{p,i}$ be the

[3]Generally, H is assumed to follow the extreme value distribution for maxima. See Gotz and McCall (1984). These simulations assumed H follows a normal probability distribution because previous work

monetary equivalent of a random shock that the pth individual receives at the ith YOS. Random shocks, $\varepsilon$, are assumed to be distributed according to a cumulative distribution function F.[4] Also, F and H are assumed to be independently distributed.

The return from leaving at the decision point i from state $s_i$ is calculated as:

$$L_{s_i} = \sum_{j=i+1}^{\infty} (cpay_{i,j} + rpay_{s_i}) \cdot \beta_{i,j} \ . \tag{A.19}$$

State $s_i$ identifies both the YOS and grade, so $rpay_{s_i}$ is well defined. State $s_i$ also identifies the promotion timing, which does not affect military pay at a given period. Returns from staying are dependent on the expected value of an individual's future military income stream, his taste value, and the random shocks he receives. Let $V(s_i, \gamma_p, \varepsilon_{p,i})$ be the expected discounted returns to following the optimal strategy for the pth individual who is in state $s_i$ at YOS i, who has a taste factor of $\gamma_p$, and who has just received a transient disturbance of $\varepsilon_{p,i}$. If he chooses to stay and if he is not involuntarily separated, he will receive the random shock $\varepsilon_{p,i}$ and move to the next YOS-grade cell according to the known transition probabilities $P_{s_i, s_{i+1}}$. He then receives a single period military compensation of $mpay_{s_{i+1}}$ and the annual value of his taste $\gamma_p$ and makes another decision to stay or leave and receives the optimal return of $V(s_{i+1}, \gamma_p, \varepsilon_{p,i+1})$.[5] Neither $s_{i+1}$ nor $\varepsilon_{p,i+1}$ are known, but the expected value of the returns to staying can be calculated as:

$$S_{p,s_i} = \epsilon_{p,i} + \sum_{r=s_i}^{N-1} \left[ P_{s_i,r} \cdot \{(mpay_r + \gamma_p) \cdot \beta_{i,i+1} + E_\epsilon[V(r,\gamma_p,\epsilon)]\} \right]$$

$$+ P_{s_i,N} \cdot \left\{ spay_{s_i} + L_i \right\} \ , \tag{A.20}$$

---

indicated that results are not very sensitive to the choice of the probability distribution function (between extreme value and normal families). (Personal communication with Glenn Gotz.)

[4] Generally, F is assumed to follow the normal probability distribution.

[5] Enlisted personnel can not make a decision every year, only at the end of their term of enlistment.

where N is the last state, which by convention is the civilian state, and $E_\varepsilon$ is the expectation with respect to the transient shock $\varepsilon$. Therefore, the value of the optimal decision in decision point i is

$$V(s_i,\gamma_p,\epsilon_{p,i}) = \max(S_{p,s_i}; L_{s_i}) \ . \tag{A.21}$$

If the promotion probabilities, civilian probabilities, and bonuses (which are part of the military pay schedule) are differentiated by individuals, $L_{s_i}$ will also have the index p, which identifies individuals.

At the HYT, the individuals must leave for the civilian state. Hence,

$$V(s_{HYT}, \cdot , \cdot ) = L_{s_{HYT}} \ , \tag{A.22}$$

which is independent of tastes and transient shocks. The cost of leaving measure at decision point i is defined as

$$COL_{s_i}(\gamma_p) = S_{p,s_i} - L_{s_i} \ . \tag{A.23}$$

An individual's subjective probability of leaving at decision point i+1, given he is still in the military at the decision point i, is given by $F(-COL_{s_{i+1}}(\gamma_p))$, where F is the cumulative distribution function for transient shock $\varepsilon$.

This probability is a function of the current state a person occupies, his taste factor, and the distribution of the random shocks. The probability of leaving at the HYT is $F(-COL_{s_{i+1}}(\gamma_p)) = 1$. Let $D_{s_i}$ denote a decision at YOS i and state $s_i$. Also let $D_{s_i} = 0$ show a leave decision and $D_{s_i} = 1$ show a stay decision. The probability of an individual staying until the mth decision point and then leaving can be calculated as

$$P\{D_{s_i} = 1, D_{s_2} = 1 \ , \ldots , \ D_{s_{m-1}} = 1, D_{s_m} = 0\}$$

$$= F(-COL_{s_m}(\gamma_p)) \cdot \prod_{n=1}^{m-1} \cdot \{1 - F[-COL_{s_n}(\gamma_p)]\} \ .$$

The retention rate for those individuals who follow a specific path through the possible states can be calculated by integrating over the distribution of tastes. Hence, the retention rate at the second decision point for individuals who followed the state path, $s_1 = s1$, $s_2 = s2$ (where s1 and s2 are specific states) is

$$P(D_{s2} = 1 | D_{s1} = 1) = \frac{\int_{-\infty}^{\infty} \left\{ \int_{-COL_{s1}(\gamma)}^{\infty} dF(\epsilon) \int_{-COL_{s2}(\gamma)}^{\infty} dF(\epsilon) \right\} h(\gamma) d\gamma}{\int_{-\infty}^{\infty} \int_{-COL_{s1}(\gamma)}^{\infty} dF(\epsilon) h(\gamma) d\gamma} \tag{A.24}$$

where $h(\gamma)$ is the density function of the persistent taste factor across the members of an entering cohort.

The retention rate for a given state depends on the previous states occupied and the previous compensation policies through the values of past costs of leaving. If that information is available, a sample likelihood function can be developed by calculating the retention probability for each state path through the model and raising those probabilities to the $n_k$th power, where k denotes different state paths and $n_k$ is the number of individuals who followed the kth path in the sample. The parameters of the DRM are estimated by searching for the parameter values that maximize the sample likelihood function.

## EFFECTS OF RANDOM SHOCKS ON RETENTION RATES

Let

| | |
|---|---|
| $P(Stay_{\gamma} \| \gamma)$ | be the probability of staying at the first decision point given *only* tastes. |
| $P(Stay_{\gamma,\varepsilon} \| \gamma,\varepsilon)$ | be the probability of staying at the first decision point given *both* tastes and random shocks. |

Also let

| | |
|---|---|
| $H(\gamma)$ | represent the cumulative distribution function of tastes among the members of a cohort. |

F(ε) represent the cumulative distribution function of random shocks.

$$h(\gamma) = \frac{dH(\gamma)}{d\gamma} \quad ; \quad f(\epsilon) = \frac{dF(\epsilon)}{d\epsilon}$$

Hence, $h(\gamma)$ and $f(\varepsilon)$ are probability density functions. Assume that $f(\varepsilon)$ is symmetric around a mean of zero.[6] Hence,

$$\int_{-\infty}^{\infty} \epsilon f(\epsilon)d\epsilon = 0 \tag{A.25a}$$

and

$$\int_{-\infty}^{-x} f(\epsilon)d\epsilon = \int_{x}^{-\infty} f(\epsilon)d\epsilon \text{ for any x} . \tag{A.25b}$$

Also let $h(\gamma)$ be a symmetric, unimodal probability distribution around its mean, θ. If the retention rate is less than 0.5 then

$$\int_{ACOL}^{\infty} h(\gamma)d\gamma < 0.5 .$$

Note that symmetry and unimodality ensures that

$$\int_{ACOL-y}^{ACOL} h(\gamma)d\gamma > \int_{ACOL}^{ACOL+y} h(\gamma)d\gamma \text{ for } y > 0 , \tag{A.26}$$

where ACOL is defined as

$$COL\ (ACOL) = 0 . \tag{A.27}$$

Probability of staying for an individual with taste $\gamma_p$ and random shock $\varepsilon_{i,p}$ is

$$P(Stay_{\gamma,\epsilon}|\gamma_p,\epsilon_{i,p}) = P(\epsilon_{i,p} + COL(\gamma_p) > 0) = P(\epsilon_{i,p} > -COL(\gamma_p)) .$$

[6] $f(\varepsilon)$ is usually assumed to be distributed normally.

Therefore, the retention rate with the random shocks is

$$\int_{-\infty}^{\infty} \left\{ \int_{-COL(\gamma)}^{\infty} dF(\epsilon) \right\} h(\gamma)d\gamma \ . \tag{A.28}$$

If the introduction of random shocks increases the retention rate then

$$\int_{-\infty}^{\infty} \left\{ \int_{-COL(\gamma)}^{\infty} dF(\epsilon) \right\} h(\gamma)d\gamma - \int_{ACOL}^{\infty} h(\gamma)d\gamma > 0 \ . \tag{A.29}$$

Equation (A.29) could equivalently be written as

$$\int_{-\infty}^{ACOL} \left\{ \int_{-COL(\gamma)}^{\infty} dF(\epsilon) \right\} h(\gamma)d(\gamma) - \int_{ACOL}^{\infty} \left\{ 1 - \int_{-COL(\gamma)}^{\infty} dF(\epsilon) \right\} h(\gamma)d\gamma \tag{A.30}$$

Because of Eq. (A.27)

$$\int_{-COL(ACOL)}^{\infty} dF(\epsilon) = \int_{0}^{\infty} dF(\epsilon) = 0.5 \ . \tag{A.31}$$

For any y > 0

$$\int_{ACOL-y}^{ACOL} [0.5 - (1 - F(ACOL - y))]h(\gamma)d\gamma - \int_{ACOL}^{ACOL+y} [1 - (F(ACOL + y) + 0.5)]h(\gamma)d\gamma$$

$$= \int_{ACOL-y}^{ACOL} [-0.5 + F(ACOL - y)]h(\gamma)d\gamma - \int_{ACOL}^{ACOL+y} [0.5 - F(ACOL + y)]h(\gamma)d\gamma$$

But because of Eq. (A.25b)

$$[-0.5 + F(ACOL - y)] = [0.5 - F(ACOL + y)] \text{ for any } y \ .$$

Also because of Eq. (A.26)

$$\int_{ACOL-y}^{ACOL} h(\gamma)d\gamma > \int_{ACOL}^{ACOL+y} h(\gamma)d\gamma \text{ for } y > 0 \ .$$

Therefore Eq. (A.30) > 0. Hence, introduction of random shocks increases the retention rate.

# Appendix B

# ACOL MODELS AND THEIR PREDICTIONS

## COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS

These tables compare the ACOL (QRMC V) predictions with simulated effects under different discount rate assumptions. They complement the tables in Section IV.

Table B.1

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 4,
DISCOUNT RATE 5 PERCENT
(COLA = CPI - 1%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | | | | | | | | |
| ACOL estimate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.020 | -.078 | -.068 | -.026 | -.007 | -.002 | 9E-04 | .019 |
| Predicted effect (ACOL) | -.005 | -.012 | -.013 | -.008 | -.022 | -.030 | -.029 | .014 |
| Predicted/simulated | .253 | .159 | .193 | .316 | 3.109 | 13.576 | -33.548 | .771 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1662 | -2793 | -3148 | -3287 | -2379 | -1141 | -336 |
| Predicted effect (ACOL) | 0 | -420 | -545 | -640 | -718 | -751 | -584 | -266 |
| Predicted/simulated | 1 | .253 | .195 | .203 | .218 | .315 | .511 | .791 |
| Manyears during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -1163 | -7329 | -11351 | -12650 | -13059 | -5240 | -2374 | -449 |
| Predicted effect (ACOL) | -294 | -1758 | -2232 | -2592 | -2877 | -2432 | -1582 | -359 |
| Predicted/simulated | .253 | .239 | .196 | .204 | .220 | .464 | .666 | .800 |

[a]95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table B.2

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 5, DISCOUNT RATE 5 PERCENT
(Flat multiplier × YOS = 50%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.014 | -.053 | -.044 | -.015 | -.126 | -.140 | -.058 | -.007 |
| Predicted effect (ACOL) | -.002 | -.003 | -.001 | -2E-04 | -.086 | -.124 | -.104 | -.026 |
| Predicted/simulated | .158 | .058 | .029 | .014 | .682 | .888 | 1.785 | 3.503 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1178 | -1967 | -2212 | -2294 | -2787 | -2075 | -722 |
| Predicted effect (ACOL) | 0 | -187 | -181 | -173 | -169 | -1101 | -1401 | -671 |
| Predicted/simulated | 1 | .159 | .092 | .078 | .074 | .395 | .675 | .929 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -824 | -5188 | -7993 | -8882 | -9226 | -7737 | -4560 | -1092 |
| Predicted effect (ACOL) | -130 | -746 | -722 | -692 | -773 | -4559 | -3757 | -1053 |
| Predicted/simulated | .158 | .143 | .090 | .077 | .083 | .589 | .823 | .964 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table B.3

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 6, DISCOUNT RATE 5 PERCENT
(Retirement eligibility at YOS 23)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| ACOL estimate | .325 | .667 | .731 | .863 | .660 | .373 | .280 | .149 |
| ACOL estimate (adjusted) | .325 | .535 | .853 | .971 | .705 | .474 | .295 | .140 |
| Simulated effect | -.017 | -.065 | -.061 | -.029 | .259 | .188 | -.016 | .004 |
| Predicted effect (ACOL) | -.004 | -.015 | -.029 | -.033 | .233 | .263 | -8E-04 | -9E-04 |
| Predicted/simulated | .249 | .229 | .489 | 1.128 | .897 | 1.397 | .047 | -.193 |
| Starting number of airmen | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Simulated effect | 0 | -1426 | -2375 | -2733 | -2925 | 178 | 1654 | 401 |
| Predicted effect (ACOL) | 0 | -354 | -575 | -891 | -1236 | 1536 | 3280 | 965 |
| Predicted/simulated | 1 | .248 | .242 | .326 | .422 | 8.629 | 1.983 | 2.406 |
| Manyears (during the term)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Simulated effect | -998 | -6275 | -9681 | -11010 | -11393 | 5712 | 3187 | 601 |
| Predicted effect (ACOL) | -248 | -1550 | -2461 | -3702 | -4668 | 9846 | 6558 | 1424 |
| Predicted/simulated | .249 | .247 | .254 | .336 | .409 | 1.723 | 2.057 | 2.370 |

[a]95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table B.4

SIMULATED EFFECTS OF POLICY 2, TAPERED DISCOUNT RATE
(1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.012 | -.062 | -.035 | -.003 | .115 | .110 | .076 | .054 |
| Predicted effect (ACOL) | -.003 | -.011 | -.006 | -5E-04 | .018 | .030 | .040 | .047 |
| Predicted/simulated | .236 | .176 | .195 | .163 | .159 | .275 | .523 | .881 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -1015 | -2185 | -2496 | -2527 | -533 | 725 | 769 |
| Predicted effect (ACOL) | 0 | -240 | -426 | -500 | -505 | -120 | 227 | 331 |
| Predicted/simulated | 1 | .236 | .195 | .200 | .200 | .225 | .313 | .431 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -710 | -4764 | -8897 | -9998 | -9912 | 724 | 2780 | 1662 |
| Predicted effect (ACOL) | -167 | -1074 | -1743 | -2003 | -1986 | 117 | 989 | 845 |
| Predicted/simulated | .236 | .225 | .195 | .200 | .200 | .162 | .355 | .508 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table B.5

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 4, TAPERED DISCOUNT RATE (COLA = CPI - 1%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.022 | -.115 | -.071 | -.006 | -.029 | -.037 | 3E-04 | .009 |
| Predicted effect (ACOL) | -.002 | -.010 | -.005 | -4E-04 | -.036 | -.040 | -.035 | .008 |
| Predicted/simulated | .129 | .087 | .083 | .068 | 1.230 | 1.090 | -103.250 | .990 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -1776 | -3883 | -4429 | -4480 | -3528 | -2382 | -808 |
| Predicted effect (ACOL) | 0 | -230 | -395 | -456 | -461 | -825 | -872 | -477 |
| Predicted/simulated | 1 | .129 | .101 | .103 | .102 | .233 | .366 | .590 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -1243 | -8372 | -15809 | -17740 | -17829 | -9021 | -5587 | -1125 |
| Predicted effect (ACOL) | -160 | -1022 | -1615 | -1829 | -1881 | -3101 | -2739 | -671 |
| Predicted/simulated | .129 | .122 | .102 | .103 | .105 | .343 | .490 | .596 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table B.6

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 5, TAPERED DISCOUNT RATE
(Flat multiplier × YOS = 50%)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.015 | -.076 | -.041 | -.001 | -.261 | -.313 | -.133 | -.064 |
| Predicted effect (ACOL) | -.001 | -.004 | -9E-04 | 1E-08 | -.103 | -.133 | -.130 | -.046 |
| Predicted/simulated | .125 | .053 | .020 | -8E-06 | .394 | .426 | .977 | .729 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -1233 | -2640 | -2984 | -3000 | -4996 | -4603 | -1761 |
| Predicted effect (ACOL) | 0 | -154 | -194 | -195 | -194 | -1544 | -2066 | -1223 |
| Predicted/simulated | 1 | .125 | .073 | .065 | .065 | .309 | .448 | .694 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -863 | -5779 | -10736 | -11945 | -12203 | -15373 | -11052 | -2669 |
| Predicted effect (ACOL) | -108 | -642 | -780 | -782 | -915 | -6365 | -6410 | -1960 |
| Predicted/simulated | .125 | .111 | .072 | .065 | .075 | .414 | .580 | .734 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table B.7

COMPARISON OF ACOL (QRMC V) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 6, TAPERED DISCOUNT RATE

(Retirement eligibility at YOS 23)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .338 | .542 | .940 | .998 | .725 | .607 | .340 | .146 |
| ACOL estimate | .338 | .719 | .770 | .897 | .734 | .456 | .320 | .171 |
| ACOL estimate (adjusted) | .338 | .542 | .940 | .998 | .725 | .606 | .339 | .145 |
| Simulated effect | -.009 | -.044 | -.029 | -.006 | .240 | .108 | -.021 | -.008 |
| Predicted effect (ACOL) | -.003 | -.015 | -.013 | -.001 | .222 | .203 | -.001 | -.002 |
| Predicted/simulated | .391 | .342 | .449 | .283 | .927 | 1.872 | .093 | .287 |
| Starting number of airmen | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Simulated effect | 0 | -722 | -1565 | -1859 | -1929 | 1454 | 2129 | 551 |
| Predicted effect (ACOL) | 0 | -282 | -561 | -714 | -736 | 2377 | 3962 | 1326 |
| Predicted/simulated | 1 | .391 | .358 | .384 | .381 | 1.634 | 1.860 | 2.406 |
| Manyears (during the term)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Simulated effect | -505 | -3396 | -6410 | -7466 | -7379 | 8460 | 4553 | 735 |
| Predicted effect (ACOL) | -197 | -1298 | -2324 | -2867 | -2634 | 11654 | 8853 | 1928 |
| Predicted/simulated | .391 | .382 | .362 | .384 | .357 | 1.377 | 1.944 | 2.622 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

## THE PARAMETER ESTIMATES OF ACOL MODELS (TRNMN AND YOS DUMMIES)

These tables show the parameter estimates of the ACOL models that were described in Sec. IV.

Table B.8

PARAMETER ESTIMATES OF ACOL (TRNMN)[a]
FROM SIMULATED DATA,[b]
DISCOUNT RATE 10 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 1.31944 | 0.02597 |
| ACOL[c] | 0.00192 | 0.00003 |
| TRNMN | -0.63008 | 0.03555 |
| ACOL×TRNMN | -0.00176 | 0.00003 |
| TRNMN×TRNMN | 0.36261 | 0.01408 |
| ACOL×TRNMN×TRNMN | 0.00041 | 0.86E-5 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(0,5001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

Table B.9

PARAMETER ESTIMATES OF ACOL (TRNMN)[a]
FROM SIMULATED DATA,[b]
DISCOUNT RATE 5 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 1.36783 | 0.02334 |
| ACOL[c] | 0.00066 | 0.86E-5 |
| TRNMN | -0.70041 | 0.03292 |
| ACOL×RNMN | -0.00053 | 0.99E-5 |
| TRNMN×RNMN | 0.27900 | 0.01237 |
| ACOL×RNMN×RNMN | 0.00011 | 0.30E-5 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belong ing to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(500,2001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

Table B.10

PARAMETER ESTIMATES OF ACOL (TRNMN)[a] FROM SIMULATED DATA,[b] DISCOUNT RATE TAPERED FROM 20 PERCENT TO 2 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | -0.03523 | 0.00758 |
| ACOL[c] | 0.00102 | 0.14E-4 |
| TRNMN | 0.60015 | 0.02145 |
| ACOL×TRNMN | -0.00101 | 0.16E-4 |
| TRNMN×TRNMN | 0.03905 | 0.01098 |
| ACOL×TRNMN×TRNMN | 0.00025 | 0.47E-5 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(1000,2001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

Table B.11

PARAMETER ESTIMATES OF ACOL (YOS DUMMIES)[a] FROM SIMULATED DATA,[b] DISCOUNT RATE 10 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 0.86240699 | 0.07493333 |
| ACOL[c] | 0.00019422 | 0.00000694 |
| YOS4 | -1.05956365 | 0.07331758 |
| YOS8 | -0.45898299 | 0.07306599 |
| YOS12 | 0.63112639 | 0.07622484 |
| YOS16 | 1.22710896 | 0.09653955 |
| YOS20 | 0.78757011 | 0.07286968 |
| YOS21 | -0.79303492 | 0.11210041 |
| YOS22 | 1.25261073 | 0.07480147 |
| YOS23 | 1.39516919 | 0.08401445 |
| YOS24 | -1.16189321 | 0.11837023 |
| YOS25 | -0.71825690 | 0.10271981 |
| YOS26 | 2.54121282 | 0.09260674 |
| YOS27 | 0.89533490 | 0.08416044 |
| YOS28 | 1.42747495 | 0.10376828 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(0,5001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

Table B.12

PARAMETER ESTIMATES OF ACOL (YOS DUMMIES)[a] FROM SIMULATED DATA,[b] DISCOUNT RATE 5 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 1.07450374 | 0.09035845 |
| ACOL[c] | 0.00029819 | 0.00000441 |
| YOS4 | -0.65539452 | 0.08912282 |
| YOS8 | -0.23277417 | 0.08954150 |
| YOS12 | 0.25966179 | 0.09362032 |
| YOS16 | -0.93473974 | 0.11882304 |
| YOS20 | 0.24126783 | 0.09113446 |
| YOS21 | -4.59837419 | 0.12857758 |
| YOS22 | 1.08773494 | 0.09205584 |
| YOS23 | 0.25904948 | 0.09833537 |
| YOS24 | -5.05977398 | 0.13249985 |
| YOS25 | -3.35843080 | 0.11687476 |
| YOS26 | 2.42951509 | 0.10229784 |
| YOS27 | 1.26775681 | 0.10235834 |
| YOS28 | 0.71055967 | 0.11759011 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(500,2001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

Table B.13

PARAMETER ESTIMATES OF ACOL (YOS DUMMIES)[a] FROM SIMULATED DATA,[b] DISCOUNT RATE TAPERED FROM 20 PERCENT TO 2 PERCENT

| Variable | Estimate | Asymptotic Standard Error |
|---|---|---|
| Intercept | 0.84170737 | 0.06814365 |
| ACOL[c] | 0.00026654 | 0.00000495 |
| YOS4 | -1.07752743 | 0.06813677 |
| YOS8 | -0.60694970 | 0.06858502 |
| YOS12 | 0.96608848 | 0.07920088 |
| YOS16 | 1.50134026 | 0.22818131 |
| YOS20 | -0.57023035 | 0.07464371 |
| YOS21 | -5.61994771 | 0.15645766 |
| YOS22 | 0.92893032 | 0.07201719 |
| YOS23 | 0.83016040 | 0.09172269 |
| YOS24 | -6.26436371 | 0.16456704 |
| YOS25 | -4.04121157 | 0.12989018 |
| YOS26 | 1.91898341 | 0.07387444 |
| YOS27 | 1.29518783 | 0.07769926 |
| YOS28 | 0.54545127 | 0.09073058 |

[a]Although tastes are distributed according to a normal distribution, the ACOL model was estimated with logistic regression to be consistent with previous work (Warner, 1979; and Enns, Nelson, and Warner, 1984). But logistic and normal probability distributions do not differ materially.

[b]Data are based on simulated decisions of 100,000 airmen, each belonging to one of 28 groups defined by different civilian and military earnings potentials. Airmen differ in their tastes toward military life according to $N(1000,2001^2)$.

[c]Annualized cost of leaving is expressed in dollars in this table.

## EFFECTS OF DIFFERENT ADJUSTMENT PROCEDURES ON PREDICTIONS

Table B.14 shows the ACOL (TRNMN) estimates when the adjustment procedure is to add the residuals from the estimation to the predictions. Comparison of this table with text Table 20 confirms the discussion about the adjustment procedures in Sec. IV.

Table B.14

COMPARISON OF ACOL (TRNMN) PREDICTIONS WITH SIMULATED EFFECTS OF POLICY 2, DISCOUNT RATE 10 PERCENT
(Adjustments made after exponentiating, 1% permanent penalty on multiplier for early retirement)

| | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| Retention rate | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .190 |
| ACOL estimate | .323 | .621 | .764 | .878 | .688 | .475 | .357 | .366 |
| ACOL estimate (adjusted) | .326 | .539 | .808 | .950 | .726 | .531 | .352 | .188 |
| Simulated effect | -.003 | -.015 | -.023 | -.014 | .062 | .071 | .044 | .028 |
| Predicted effect (ACOL) | -.007 | -.002 | -.017 | -.031 | .046 | .029 | .006 | .014 |
| Predicted/simulated | 2.498 | .182 | .760 | 2.109 | .746 | .407 | .139 | .519 |
| Starting number of airmen | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Simulated effect | 0 | -246 | -536 | -752 | -875 | -11 | 560 | 407 |
| Predicted effect (ACOL) | 0 | -617 | -404 | -571 | -886 | -179 | 31 | 37 |
| Predicted/simulated | 1 | 2.502 | .753 | .759 | 1.012 | 16.272 | .055 | .091 |
| Manyears (during the term)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Simulated effect | -172 | -1161 | -2255 | -3061 | -3415 | 1077 | 1704 | 807 |
| Predicted effect (ACOL) | -431 | -2345 | -1701 | -2413 | -3474 | -77 | 380 | 153 |
| Predicted/simulated | 2.498 | 2.018 | .754 | .788 | 1.017 | -.071 | .223 | .190 |

[a] 95% of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

## THE MEAN OF A TRUNCATED NORMAL DISTRIBUTION

This section describes the calculation of the taste proxy, TRNMN, which was used for the improved ACOL model.

### Calculation of the Truncated Mean Variable (TRNMN)

Assume that tastes, $\gamma$, are distributed normally at the first decision point, $N(\theta,\omega)$. Also assume that financial returns and tastes are the only factors influencing the retention decision. Then at the first decision point all individuals whose tastes are less than the negative of annualized cost of leaving, -ACOL, would leave. At the second decision point the remaining population will have a truncated normal distribution, $h(\gamma)$. Where

$$h(\gamma) = \begin{cases} 0 & \text{if } \gamma < -ACOL \\ \frac{K}{\sqrt{2\pi}\,\omega} \exp\left[-\frac{1}{2}\left(\frac{\gamma-\theta}{\omega}\right)^2\right] & \text{if } \gamma > -ACOL \end{cases}$$

K is determined from the condition $\int h(\gamma)d\gamma = 1$ and thus

$$K = \left[1 - \Phi\left(\frac{-ACOL - \theta}{\omega}\right)\right]^{-1}$$

where $\Phi(\gamma)$ is the cumulative normal distribution.

The expected value of tastes at the second decision point could be calculated as

$$E(\gamma) = \int_{-\infty}^{\infty} \gamma h(\gamma)d\gamma = \frac{1}{1-\Phi[(-ACOL-\theta)/\omega]} \int_{-ACOL}^{\infty} \frac{\gamma}{\sqrt{2\pi}\,\omega} \exp\left[-\frac{1}{2}\left(\frac{\gamma-\theta}{\omega}\right)^2\right]d\gamma$$

$$= \theta + \frac{\omega}{1-\Phi[(-ACOL-\theta)/\omega]} \frac{1}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{-ACOL-\theta}{\omega}\right)^2\right]$$

P(Stay at first decision point) = $1 - \Phi[(-ACOL - \theta)/\omega]$. Therefore the increase in the mean of the truncated distribution is proportional to

$$\Delta taste \propto \frac{\omega}{P(Stay_{Prev})} \exp\left[-\frac{1}{2}\left(\Phi^{-1}(P(Stay_{Prev})\right)^2\right]$$

Hence, the variable that was included in the regressions was calculated as

$$\mathrm{TRNMN} = \frac{1}{P(\mathrm{Stay}_{\mathrm{Prev}})} \exp\left[-\tfrac{1}{2}\left(\Phi^{-1}P(\mathrm{Stay}_{\mathrm{Prev}})\right)^{2}\right]$$

where $P(\mathrm{Stay}_{\mathrm{Prev}})$ is the cumulative probability of having stayed until the current decision point. It equals the proportion of the entering cohort that is still in the military to make a stay/leave decision.

# Appendix C

# AGGREGATE RETENTION EFFECTS OF RETIREMENT POLICIES

In Sec. VI, the disaggregation of retention effects of Policy 2 showed that a new retirement policy could have very different effects on groups facing different civilian, promotion, and bonus opportunities. However, retention rates are more heavily influenced by YOS and assumptions about the discount rates. This appendix will discuss the retention effects of other policies that were analyzed (many hypothetical) by looking at their effects on different YOS and by different discount rate assumptions.

## POLICY 3 (1 PERCENT TEMPORARY PENALTY ON MULTIPLIER)

In Policy 3 the penalty on the multiplier for early retirement lasts only until the 30th anniversary of the initial enlistment date. Therefore, it should have a similar pattern of changes in the retention rates as Policy 2, but the changes should be smaller. Table C.1 confirms this argument.

## POLICY 4 (COLA = CPI - 1 PERCENT)

In Policy 4 the CPI was assumed to increase at 4 percent per year and the retirement benefits at 3 percent per year. Table C.2 shows that this policy has slightly larger effects than Policy 2 before retirement eligibility. But because it does not provide additional incentives to stay longer in the retirement years (except to delay the erosion in retirement pay), the number of airmen staying in the retirement years is less than in the current system. Disaggregation of the effects of Policy 4 by different civilian income opportunities shows (Table C.3) that at YOS 12, although the retention rate of those with higher civilian income opportunities is closer to 50 percent than those with average civilian opportunities, Policy 4 has a smaller effect on those with high civilian income opportunities. The proportion of those who stay with the military despite their high civilian opportunities is

Table C.1

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 3
(1% temporary penalty on multiplier for early retirement)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .191 |
| Effect of Policy 3 | -.002 | -.009 | -.013 | -.009 | .049 | .049 | .021 | .006 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 3 | 0 | -161 | -332 | -459 | -533 | 124 | 462 | 265 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 3 | -113 | -749 | -1394 | -1867 | -2068 | 1097 | 1262 | 474 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| Effect of Policy 3 | -.007 | -.023 | -.018 | -.007 | .046 | .053 | .020 | .009 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 3 | 0 | -572 | -905 | -1016 | -1064 | -258 | 301 | 175 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 3 | -400 | -2490 | -3677 | -4086 | -4178 | 267 | 891 | 313 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 3 | -.005 | -.021 | -.011 | -2E-04 | .067 | .057 | .021 | .004 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 3 | 0 | -376 | -784 | -895 | -896 | 226 | 730 | 392 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 3 | -263 | -1752 | -3195 | -3581 | -3476 | 1744 | 2147 | 654 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table C.2

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 4
(COLA = CPI - 1%)[a]

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .951 | .726 | .531 | .353 | .191 |
| Effect of Policy 4 | -.004 | -.020 | -.029 | -.019 | .011 | .015 | .018 | .031 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 4 | 0 | -326 | -701 | -968 | -1119 | -704 | -264 | -21 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 4 | -228 | -1530 | -2941 | -3933 | -4435 | -1421 | -467 | 61 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .140 |
| Effect of Policy 4 | -.021 | -.078 | -.068 | -.026 | -.007 | -.002 | 9E-04 | .019 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 4 | 0 | -1662 | -2793 | -3148 | -3287 | -2379 | -1141 | -336 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 4 | -1163 | -7329 | -11351 | -12650 | -13059 | -5240 | -2374 | -449 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 4 | -.022 | -.115 | -.071 | -.006 | -.029 | -.037 | 3E-04 | .009 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 4 | 0 | -1776 | -3883 | -4429 | -4480 | -3528 | -2382 | -808 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 4 | -1243 | -8372 | -15809 | -17740 | -17829 | -9021 | -5587 | -1125 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table C.3

COMPARISON OF RETENTION EFFECTS BY DIFFERENT CIVILIAN INCOME OPPORTUNITIES, POLICY 4, DISCOUNT RATE 10 PERCENT (COLA = CPI - 1%)

| Civilian Opportunity | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20 | YOS 23 | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| High[a] | | | | | | | | |
| Retention rate (current) | .252 | .367 | .741 | .918 | .732 | .468 | .303 | .175 |
| Effect of Policy 4 | -.001 | -.012 | -.027 | -.042 | .002 | .017 | .027 | .050 |
| Average[b] | | | | | | | | |
| Retention rate (current) | .326 | .528 | .798 | .947 | .717 | .527 | .366 | .194 |
| Effect of Policy 4 | -.004 | -.019 | -.032 | -.019 | .011 | .014 | .016 | .026 |
| Low[c] | | | | | | | | |
| Retention rate (current) | .416 | .665 | .870 | .960 | .768 | .573 | .394 | .207 |
| Effect of Policy 4 | -.005 | -.024 | -.021 | -.013 | .009 | .019 | .018 | .058 |

[a] 10 percent higher than the average.

[b] Average for the entering cohort.

[c] 10 percent lower than the average.

smaller, and on the average they must have much higher tastes for the military than those with lower civilian income opportunities.

## POLICY 5 (FLAT, MULTIPLIER × YOS = 50%)

This policy penalizes (compared with the current policy) those who stay more than 20 YOS because the multiplier does not increase after YOS 20. Therefore, its biggest effect is on the retirement years (see Table C.4). It reduces the number of manyears served by those who are between YOS 20 and 30 by about 25 percent (under tapered and low discount rate assumptions). But there are also significant reductions in the retention rates at the earlier YOS. The ACOL model cannot explain these earlier losses because it is a maximum regret model. Such a policy change is unlikely to be implemented.

## POLICY 6 (ELIGIBILITY AT YOS 23)

This policy delays the retirement eligibility to YOS 23. To show the effect of this policy on the number of airmen who reach retirement eligibility another column (YOS 22) was added to Table C.5. Now the row for number of airmen under YOS 23 shows how many started YOS 23 rather than the three year period YOS 21-23 as given in other tables. Most of the extra losses due to this policy occur at the earlier YOS. About 90 percent of those who stay until YOS 16 make it to retirement eligibility. Furthermore, more airmen stay after the 23rd YOS than under the current system for two reasons. Civilian income opportunities decline with YOS, and expectation of a large retirement benefit helps airmen stay through large negative random shocks.

## POLICY 7 (PAYMENTS DELAYED UNTIL YOS 30)

Table C.6 shows the effect of Policy 7 under different discount rate assumptions. This policy, not starting the retirement pay until the 30th anniversary of first enlistment (although keeping the eligibility requirement the same), has the greatest effect on retention rates among the policies analyzed. It reduces the number of manyears served by personnel at certain YOS (for example, 17-20) by as much as 20 percent (with a 10 percent discount rate assumption). This effect gets

Table C.4

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 5
(Flat multiplier × YOS = 50%)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .950 | .726 | .531 | .353 | .191 |
| Effect of Policy 5 | -.003 | -.014 | -.021 | -.012 | -.082 | -.087 | -.018 | .005 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 5 | 0 | -223 | -489 | -683 | -781 | -1400 | -1308 | -516 |
| Manyears (current)[c] | 82290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 5 | -156 | -1052 | -2055 | -2773 | -3189 | -4433 | -3093 | -837 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| Effect of Policy 5 | -.014 | -.053 | -.044 | -.015 | -.126 | -.140 | -.058 | -.008 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 5 | 0 | -1178 | -1967 | -2212 | -2294 | -2787 | -2075 | -722 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 5 | -824 | -5188 | -7993 | -8882 | -9226 | -7737 | -4560 | -1092 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 5 | -.015 | -.076 | -.041 | -.002 | -.261 | -.313 | -.133 | -.064 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 5 | 0 | -1233 | -2640 | -2984 | -3000 | -4996 | -4603 | -1761 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 5 | -863 | -5779 | -10736 | -11945 | -12203 | -15373 | -11052 | -2669 |

[a]95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b]The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c]Manyears refer to the period ending at the YOS indicated by the column.

Table C.5

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 6
(Retirement eligibility at YOS 23)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 22 | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .951 | .726 | .689 | .771 | .353 | .768 |
| Effect of Policy 6 | -.005 | -.023 | -.036 | -.031 | .233 | .307 | -.079 | -.021 | -.006 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 5428 | 4190 | 1480 |
| Effect of Policy 6 | 0 | -396 | -827 | -1152 | -1421 | 1162 | 3576 | 2046 | 587 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 13326 | 4809 | 8968 | 2423 |
| Effect of Policy 6 | -277 | -1845 | -3474 | -4717 | -5427 | 4717 | 2811 | 4152 | 897 |
| 5% | | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .639 | .741 | .297 | .141 |
| Effect of Policy 6 | -.017 | -.065 | -.061 | -.029 | .259 | .359 | -.078 | -.016 | .004 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 5213 | 3868 | 1151 |
| Effect of Policy 6 | 0 | -1426 | -2375 | -2733 | -2925 | 178 | 3108 | 1654 | 401 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 13322 | 4541 | 7766 | 1710 |
| Effect of Policy 6 | -998 | -6275 | -9681 | 11010 | -11393 | 3331 | 2381 | 3187 | 601 |
| 20%-2% | | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .746 | .813 | .340 | .146 |
| Effect of Policy 6 | -.009 | -.044 | -.029 | -.006 | .240 | .253 | -.097 | -.021 | -.008 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 7474 | 6077 | 2066 |
| Effect of Policy 6 | 0 | -722 | -1565 | -1859 | -1929 | 1454 | 3989 | 2129 | 551 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 17524 | 6775 | 13687 | 3045 |
| Effect of Policy 6 | -505 | -3396 | -6410 | -7466 | -7379 | 5401 | 3059 | 4553 | 735 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table C.6

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 7
(Retirement payments delayed until YOS 30)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .951 | .726 | .531 | .353 | .191 |
| Effect of Policy 7 | -.010 | -.051 | -.081 | -.069 | .141 | .199 | .162 | .189 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 7 | 0 | -817 | -1740 | -2402 | -2914 | -993 | 847 | 1116 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 7 | -572 | -3825 | -7294 | -9817 | -11465 | 170 | 3537 | 2960 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| Effect of Policy 7 | -.036 | -.136 | -.148 | -.075 | .126 | .195 | .167 | .169 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 7 | 0 | -2879 | -4695 | -5380 | -5714 | -3293 | -613 | 363 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 7 | -2015 | -12609 | -19127 | -21655 | -22618 | -5500 | -86 | 1203 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 7 | -.026 | -.145 | -.106 | -.015 | .154 | .172 | .178 | .225 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 7 | 0 | -2152 | -4786 | -5560 | -5684 | -2867 | -507 | 818 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 7 | -1506 | -10189 | -19535 | -22292 | -22455 | -4730 | 654 | 2858 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

as large as 50 percent with tapered and low discount rate assumptions, indicating the importance of the retirement benefits as a retention incentive.

## POLICY 8 (HIGH-THREE BASIC PAY)

This policy has already been implemented for those who entered the military after September 1980 where the base pay in retirement pay calculations is based on the average base pay in the highest three years (usually the last three years) rather than on the final base pay. Some personnel managers in the Air Force indicated that they did not see any effects after this policy was implemented. Table C.7 indicates that the retention effects of this policy are very small. Other unmodeled factors, such as high unemployment rates in the civilian sector, could easily overcome the minor reductions in the retention rates due to this policy.

## POLICY 9 (COLA AND MULTIPLIER PENALTY)

In Policy 9, the multiplier for the first 20 YOS is 2.25 percentage points per year and then it increases to 3.0 percentage points for each year between YOS 20 and 30. Also the COLA is restricted to 1 percentage point less than the increase in CPI (which was assumed to grow at 4 percent per year) until age 62, then full COLA protection is provided. Table C.8 summarizes the effects of this policy. The retention effects are smaller at the earlier YOS, but they increase up to 30 percent of the manyears served by airmen with YOS 17-20 under the current system (with tapered and low discount rate assumptions). Nevertheless, the effect of this policy is less than the sum of the effects of Policy 2 and Policy 4 for two reasons. First, the penalty on the multiplier for early retirement is smaller in this policy than in Policy 2, and the reduction in COLA protection applies only until age 62 rather than lifetime as in Policy 4. Second, those who remain in military service even after reduction to the retirement pay would, on the average, have greater tastes for the military than those who stayed before the reduction. When further reduction is implemented, they will be affected to a lesser extent.

Table C.7

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 8
(Base pay = average of highest three years' base pay)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .951 | .726 | .531 | .353 | .191 |
| Effect of Policy 8 | -4E-04 | -.001 | -.002 | -.001 | -.004 | .003 | .015 | .013 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 8 | 0 | -31 | -66 | -86 | -100 | -118 | -38 | 52 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 8 | -21 | -146 | -276 | -353 | -403 | -297 | -344 | 190 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| Effect of Policy 8 | -.002 | -.007 | -.005 | -.001 | -.007 | .003 | .016 | .009 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 8 | 0 | -168 | -263 | -290 | -299 | -287 | -107 | 31 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 8 | -117 | -730 | -1067 | -1165 | -1196 | -665 | -518 | 143 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 8 | -.002 | -.011 | -.004 | -4E-05 | -.019 | -.008 | .038 | .021 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 8 | 0 | -200 | -399 | -431 | -431 | -569 | -425 | 75 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 8 | -140 | -922 | -1613 | -1725 | -1738 | -1653 | -1896 | 461 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

Table C.8

COMPARISON OF SIMULATED RETENTION RATES
UNDER THE CURRENT POLICY AND POLICY 9
(Restricted COLA until age 62 and multiplier penalty for early retirement)

| Discount Rate | YOS 4 | YOS 8 | YOS 12 | YOS 16 | YOS 20[a] | YOS 23[b] | YOS 26 | YOS 29 |
|---|---|---|---|---|---|---|---|---|
| 10% | | | | | | | | |
| Retention rate (current) | .326 | .539 | .808 | .951 | .726 | .531 | .353 | .191 |
| Effect of Policy 9 | -.005 | -.024 | -.037 | -.025 | .041 | .050 | .041 | .040 |
| Starting number of airmen (current) | 80000 | 26129 | 14091 | 11398 | 10838 | 7878 | 4190 | 1480 |
| Effect of Policy 9 | 0 | -406 | -847 | -1181 | -1380 | -615 | 36 | 189 |
| Manyears (current)[c] | 282290 | 97294 | 55019 | 45369 | 43057 | 18135 | 8968 | 2423 |
| Effect of Policy 9 | -284 | -1889 | -3556 | -4805 | -5447 | -732 | 400 | 473 |
| 5% | | | | | | | | |
| Retention rate (current) | .325 | .535 | .853 | .971 | .705 | .474 | .297 | .141 |
| Effect of Policy 9 | -.022 | -.084 | -.076 | -.030 | .034 | .048 | .031 | .031 |
| Starting number of airmen (current) | 80000 | 26058 | 13952 | 11903 | 11559 | 8155 | 3868 | 1151 |
| Effect of Policy 9 | 0 | -1830 | -3027 | -3416 | -3577 | -2251 | -781 | -134 |
| Manyears (current)[c] | 282241 | 96969 | 54783 | 47476 | 45896 | 17863 | 7766 | 1710 |
| Effect of Policy 9 | -1280 | -8039 | -12305 | -13731 | -14177 | -4390 | -1381 | -82 |
| 20%-2% | | | | | | | | |
| Retention rate (current) | .338 | .542 | .941 | .998 | .725 | .607 | .340 | .146 |
| Effect of Policy 9 | -.021 | -.113 | -.071 | -.007 | .047 | .048 | .048 | .051 |
| Starting number of airmen (current) | 80000 | 27048 | 14684 | 13816 | 13799 | 10009 | 6077 | 2066 |
| Effect of Policy 9 | 0 | -1751 | -3822 | -4366 | -4424 | -2767 | -1328 | -223 |
| Manyears (current)[c] | 282933 | 100772 | 58302 | 55256 | 54817 | 24300 | 13687 | 3045 |
| Effect of Policy 9 | -1225 | -8249 | -15562 | -17489 | -17533 | -6077 | -2663 | -29 |

[a] 95 percent of the airmen who start the term covering YOS 17-20 do not leave until the end of YOS 20. Therefore, starting airmen in YOS 20 column are very close to the number of airmen reaching retirement eligibility.

[b] The number of airmen starting to serve during the period covering YOS 21-23 is the number of airmen staying past the first opportunity to retire (under the current system).

[c] Manyears refer to the period ending at the YOS indicated by the column.

# Appendix D

## RECOMMENDATIONS OF MAJOR STUDIES OF THE MILITARY RETIREMENT SYSTEM

This appendix is based on App. B of Vol. I-A of QRMC V (1984) and "Modifying Military Retirement: Alternative Approaches," CBO, 1984.

### A. Hook Commission, 1948

1. *Retirement Eligibility*
   a. Officers.
      (1) At age 60 with 20 or more years of service.
      (2) At any age with 30 or more years of service.
   b. Enlisted Members
      (1) At age 50 with 20 or more years of service.
      (2) At any age with 30 or more years of service.
      (3) Service may allow retirement at 25 years of service as "needs of service."
2. *Formula for Retired Pay.* At a rate of 2.5 percent per year not to exceed 75 percent of basic pay.
3. *Contributory.* No.
4. *Vesting.* No, but with provision for severance pay.
5. *Severance Pay.*
   a. Years-of-Service 0-4. One-half month's basic pay times total years of active service.
   b. Years-of-Service 5-9. 2.5 months' basic pay plus one month's basic pay times number of years of active service over 5.
   c. Years-of-Service 10 and over. 7.5 months' basic pay plus 1.5 months' basic pay times number of years of service over 10, not to exceed 2 years' basic pay.
6. *Social Security.* No offset.
7. *Transition and Save Pay.* Five-year phase-in period from enactment, allowing member to elect either Hook plan or current Service retirement plan.

8. *Adjustment Mechanism.* None.

## B. The Gorham Report/Randall Panel, 1962

1. *Retirement Eligibility.* No changes.
2. *Formula for Retired Pay.* No changes.
3. *Contributory.* No.
4. *Vesting.* No.
5. *Severance Pay.* No changes.
6. *Social Security.* No offset.
7. *Transition and Save Pay.* None.
8. *Adjustment Mechanism.* Based on CPI.

## C. First Quadrennial Review of Military Compensation, 1967

1. *Retirement Eligibility.*
   a. Step 1. Retire at 20 YOS with immediate annuity ranging from 24 percent at 20 YOS to 51 percent at 30 YOS.
   b. Step 2. Annuity is paid based on inverse function (age 55 at 30 YOS to age 60 at 20 YOS) or when the age requirement is met after Step 1 retirement.
2. *Formula for Retired Pay.*
   a. Step 1. Percentage of "high one" salary based on YOS 20 to 40.
   b. Step 2. Increase retired pay up to 9 percent based on YOS and age by inverse function.
3. *Contributory.* Yes, 6.5 percent of "comparability salary."
4. *Vesting.* Yes, member is vested to the amount of contribution.
5. *Severance Pay.* Lump sum after 10 YOS. No formula specified.
6. *Social Security.* Integration formula needed to provide equal benefit to members with same time in service. Contribution to retirement to include social security. Retirement offset by 50 percent of social security benefit.
7. *Transition and Save Pay.* Five-year phase-in.

8. *Adjustment Mechanism.* Based on CPI.

D. **Interagency Committee (IAC), 1971**

1. *Retirement Eligibility.* Reduced annuity for members retiring with less than 30 YOS (based on age and YOS); increased to full amount when member attains age threshold.
2. *Formula for Retired Pay.* Through year 24, 2.5 percent; 3 percent per year for years 25-30, 2 percent per year for years 31-35. Max: 88 percent of HI-3 basic pay.

    Reduction: A 2 percent reduction in retired pay for each year under the threshold of age 60 for 20-24 YOS, or age 55 for 25 or more YOS. Reduction is lifted when member reaches age threshold. Example: For retirement with 20 YOS at age 42, "normal" retired pay is reduced by 36 percent (2 percent times 18 years under the age 60 threshold); the reduction is lifted at age 60.
3. *Contributory.* No.
4. *Vesting.* Yes, at 10 YOS; deferred annuity age 60 or lump sum.
5. *Severance Pay.* Lump sum over 5 YOS (5 percent of final basic pay times YOS) for involuntary separation, officer and enlisted personnel.
6. *Social Security.* Yes, 50 percent offset at age 60.
7. *Transition and Save Pay.* Transition accomplished within 10 pay raises following implementation.
8. *Adjustment Mechanism.* CPI.

E. **Retirement Modernization Act (RMA), 1972**

1. *Retirement Eligibility.* Reduced annuity for members retiring with less than 30 YOS (two-step annuity); increased to full amount when member would have attained 30 YOS.
2. *Formula for Retired Pay.* At 2.5 percent per year through year 24; 3 percent per year for years 25-30. Max: 78 percent of HI-1 basic pay.

    Reduction: For retirements with less than 30 YOS, multiplier is reduced 15 percentage points. Reduction is lifted at point where member would have attained 30 YOS. Example: for retirement with 20 YOS, the "normal" 50 percent multiplier is reduced to 35 percent initially; increased to 50 percent ten years after retirement. Maximum: 80 percent of HI-3 basic pay when attain 30-year retirement.

3. *Contributory*. No.
4. *Vesting*. At 10 YOS; provides deferred annuity age 60.
5. *Severance Pay*. Vests after five YOS. Deferred annuity starting at age 60, plus one lump-sum readjustment payment; or two lump-sum payments (one for equity and one for readjustment).
6. *Social Security*. Yes, 50 percent offset when old age annuity received.
7. *Transition and Save Pay*. Based on number of years under new system before 20 YOS.
8. *Adjustment Mechanism*. CPI.

F. **Third Quadrennial Review of Military Compensation, 1975-76**

1. *Retirement Eligibility*. Reduced annuity for members retiring with less than 30 YOS (two-step annuity); increased to full amount when member would have attained 30 YOS.
2. *Formula for Retired Pay*. At 2.55 per year through year 24; three percent per year for years 25-30. Max: 78 percent of HI-1 basic pay.

   Reduction: For retirements with less than 30 YOS, multiplier is reduced 15 percentage points. Reduction is lifted at point where member would have attained 30 YOS. Example: for retirement with 20 YOS, the "normal" 50 percent multiplier is reduced to 35 percent initially; increased to 50 percent ten years after retirement.
3. *Contributory*. No.

4. *Vesting.* At 10 YOS; provides deferred annuity age 60.
5. *Severance Pay.* Vests after five YOS. Deferred annuity starting age 60 plus lump-sum readjustment payment; or two lump-sum payments (one for equity and one for readjustment).
6. *Social Security.* None.
7. *Transition and Save Pay.* Based on number of years under new system before 20 YOS.
8. *Adjustment Mechanism.* CPI.

G. **Defense Manpower Commission (DMC), 1975-76**

1. *Retirement Eligibility.* Between 20 and 30 YOS based on time in combat or noncombat jobs (1.5 credits for each year in combat job, one point per year in noncombat job).
2. *Formula for Retired Pay.*
   a. Maximum: 80 percent of HI-3 basic pay when attain 30 retirement points; 2-2/3 percent per retirement point.
   b. Reduction: Permanent actuarial reduction in retired pay for member who retires with 30 points and elects to receive retired pay before the 30-year point.
3. *Contributory.* No.
4. *Vesting.* At 10 YOS; deferred annuity age 60.
5. *Severance Pay.* Lump sum over 10 YOS for involuntary separation, officer and enlisted personnel.
6. *Social Security.* No offset. Formula for retired pay should consider social security benefit.
7. *Transition and Save Pay.* Changes would be prospective; would not apply to those already in the Service.
8. *Adjustment Mechanism.* CPI.

H. **Aspin Retirement Proposal, 1976.** Congressman Aspin introduced a bill in the 94th Congress, 2d Session, to reform the Service retired pay system and subsequently released a study conducted by his staff. It would have changed the Uniformed Services retirement system to a civilian type of old-age pension; no retired pay until 55-60 years of age for voluntary retirement and an annuity reduction based on second-career income.

1. *Retirement Eligibility.* Voluntary retirement at age 55 with 30 or more years of service; age 60 with 20-29 years of service.
2. *Formula for Retired Pay.*
   a. 1.5 percent for 1-5 years, 1.75 percent for years 6-10, and 2 percent for 20 over 10 years.
   b. Based on highest three years' average of Regular Military Compensation (RMC).
   c. Voluntary. No retired pay until:
      (1) age 62 with 5-19 years of service,
      (2) age 60 with 20-29 years of service, or
      (3) age 55 with 30 or more years of service.
   d. Involuntary. Immediate annuity reduced by one dollar for each two dollars of other earnings until age threshold.
3. *Contributory.* No.
4. *Vesting.* Vests after five years based on rules above.
5. *Severance Pay.* None.
6. *Social Security.* No offset.
7. *Transition and Save Pay.* Based on number of years under new system before 20 YOS.
8. *Adjustment Mechanism.* CPI with minor changes.

I. **President's Commission on Military Compensation (PCMC), 1978**

1. *Retirement Eligibility.* Based upon age and YOS.
2. *Formula for Retired Pay.*
   a. 2 percent for 1-5 YOS, 2.25 percent for 6-10 YOS, and 2.75 percent for 11-35 YOS.
   b. Maximum. 90 percent of HI-3 basic pay in past 10 YOS. Member can convert a portion of retirement account to current income; when leaving active duty, member can opt for deferred or accelerated receipt of vested amount.
3. *Contributory.* No.

4. *Vesting.* At 10 YOS.
5. *Severance Pay.* After five YOS for involuntary separation, officer and enlisted personnel.
6. *Social Security.* Varying offset based on YOS (25 percent-37.5 percent) to begin at age 62 or 65.
7. *Transition and Save Pay.* With 5 or more YOS may retire under old rules.
8. *Adjustment Mechanism.* CPI.

J. **Uniformed Services Retirement Benefits Act (USRBA), 1979**

1. *Retirement Eligibility.* Two-tier EARLY WITHDRAWAL system.
2. *Formula for Retired Pay.* First tier at completion of 20 YOS; second tier begins at age 60; vested to all members completing 10+ YOS (but 20-25 percent reduction for 20-year career compared with current system and 10-15 percent reduction for 30-year career, depending on grade). Maximum: 76.25 percent of HI-2 basic pay.
3. *Contributory.* No.
4. *Vesting.* At 10 YOS.
5. *Severance Pay.* Severance pay after five YOS for involuntary separation, officer and enlisted personnel.
6. *Social Security.* Varying offset based on YOS to begin at age 62 or 65.
7. *Transition and Save Pay.* Members on active duty on date of enactment have choice of old or new system.
8. *Adjustment Mechanism.* CPI.

K. **President's Private Sector Survey on Cost Control (Grace Commission) Task Force on Department of the Air Force, 1983**

1. *Retirement Eligibility.*
   a. Immediate annuity available only after 30 years of service.
   b. Deferred annuity payable at age 60 for 20-29 years of service.
2. *Formula for Retired Pay.*

   a. 1.3 percent of HI-3 average Basic Military Compensation (BMC) per year of service.
   b. Maximum: 39 percent of HI-3.
3. *Contributory.* No.
4. *Vesting.* No.
5. *Severance Pay.* No change.
6. *Social Security.* No offset.
7. *Transition and Save Pay.*
   a. Persons in Service at implementation receive 2.55 or basic pay for prior service; 1.3 percent BMC for subsequent years.
   b. Persons over 10 YOS retain right to immediate annuity at 20 YOS.
8. *Adjustment Mechanism.* None.

## L. President's Private Sector Survey of Cost Control (Grace Commission) Task Force on Office of Secretary of Defense, 1983

1. *Alternative 1 (OSD 23B).* Current system retained but offset one dollar of retired pay for person under age 62. Four-year stepped transition from one-for-four to one-for two. Replaces dual compensation restrictions. 37.5 percent maximum social security integration (1.25 percent per year for 20 to 30 YOS).
2. *Alternative 2 (OSD 24A).*
   a. *Retirement Eligibility.* No changes.
   b. *Formula for Retired Pay.*
      (1) 2.5 percent for each year of service; maximum: 75 percent of HI-3 average basic pay.
      (2) Reduce retiree annuity of those leaving before 30 YOS at 0.5 percent per month.
   c. *Contribution.* No.
   d. *Vesting.* Yes, at 12 YOS with annuity payable at age 65, or as early as age 55 but reduced by 0.5 percent per month short of age 65.

e. *Severance Pay.* None for persons over 12 YOS.

f. *Social Security.* Maximum offset of 37.5 percent (1.25 percent per year).

g. *Transition and Save Pay.* All persons over 12 YOS remain under current system, all others on new system.

h. *Adjustment Mechanism.* CPI at start of immediate annuity, but not until age 55 for deferred benefit from 12-19 years early vesting.

M. **Recommendations of the Fifth Quadrennial Review of Military Compensation (QRMC V), 1984**

1. *Financing.* Accrual funding, according to current law.
2. *Minimum Eligibility Requirement:* 20 YOS.
3. *Base for Calculating Retired Pay.* Final basic pay for members entering service before September 8, 1980. Average of HI-3 basic pay otherwise.
4. *Method for Calculating Retired Pay.* 2.5 percent of retired pay base per year of service; 3 percent reduction for each year that YOS at retirement are short of 30 YOS.
5. *Maximum Retired Pay.* 75 percent of retired pay base for 30 YOS.
6. *Social Security Offset.* No.
7. *Severance Pay.* No change from current system.
8. *Cost-of-Living Adjustment (COLA).* 3/4 COLA for all retirees under age 62. Full COLA thereafter, but no restoral of retired pay base.
9. *Cash Withdrawal Payments.* Members retiring after 20 or more YOS receive cash withdrawal payments at retirement equal to final basic pay multiplied by two (for officers) or three (for enlisteds). After the completion of 20 YOS but before retirement, members may elect interest-only loans up to the cash withdrawal amount.

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