

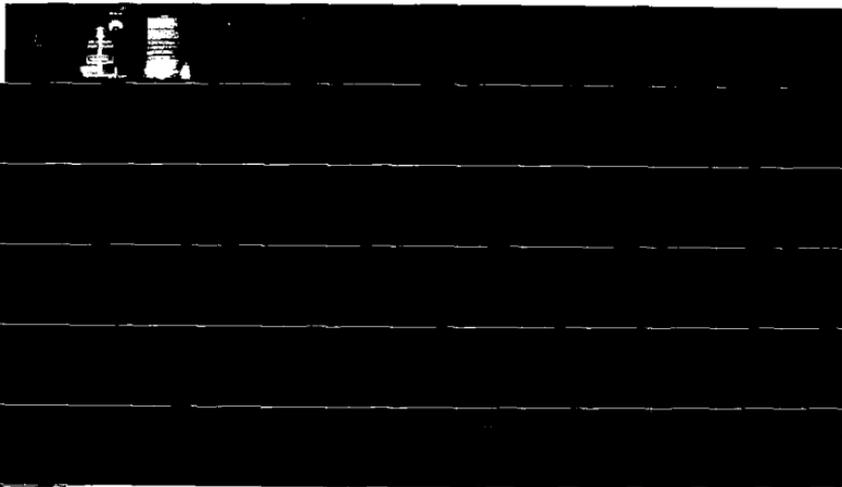
AD-A182 081 THE DPAC COMPENSATION MODEL: AN INTRODUCTORY HANDBOOK
(U) AIR COMMAND AND STAFF COLL MAXWELL AFB AL
J M NORRIS APR 87 ACSC-87-1880

1/1

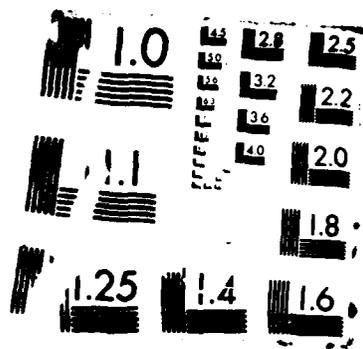
UNCLASSIFIED

F/G 5/3

ML



END
DATE
FILMED
8



AD-A182 081

THE COMPASS
AND THE GLOBE





Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	

REPORT NUMBER 87-1880

TITLE THE DPAC COMPENSATION MODEL: AN INTRODUCTORY HANDBOOK

AUTHOR(S) MAJOR JAMES M. NORRIS, USAF

FACULTY ADVISOR MAJOR DENNIS ALFORD, ACSC/3824 STUS (34)

SPONSOR LT COL D. RICHARD KATNIK, AF/DPAC

Submitted to the faculty in partial fulfillment of requirements for graduation.

**AIR COMMAND AND STAFF COLLEGE
AIR UNIVERSITY
MAXWELL AFB, AL 36112**

A182081

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION/AVAILABILITY OF REPORT STATEMENT "A" Approved for public release; Distribution is unlimited.		
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE				
4. PERFORMING ORGANIZATION REPORT NUMBER(S) 87-1880		5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION ACSC/EDCC	6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION		
6c. ADDRESS (City, State, and ZIP Code) Maxwell AFB AL 36112-5542		7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	8b. OFFICE SYMBOL (if applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8c. ADDRESS (City, State, and ZIP Code)		10. SOURCE OF FUNDING NUMBERS		
		PROGRAM ELEMENT NO.	PROJECT NO.	
		TASK NO.	WORK UNIT ACCESSION NO.	
11. TITLE (Include Security Classification) THE DPAC COMPENSATION MODEL: AN INTRODUCTORY HANDBOOK (U)				
12. PERSONAL AUTHOR(S) Norris, James M., Major, USAF				
13a. TYPE OF REPORT	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) 1987 April	15. PAGE COUNT 81	
16. SUPPLEMENTARY NOTATION				
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP			SUB-GROUP
19. ABSTRACT (Continue on reverse if necessary and identify by block number) The Personnel Analysis Center of the Directorate of Personnel Plans, Deputy Chief of Staff for Personnel, Headquarters US Air Force (AF/DPAC), is responsible for analyzing the effects of a wide range of current and proposed AF personnel and compensation policies. A fundamental tool DPAC uses in its analyses of compensation policies is a multi-option, interactive computer program known as the "Compensation Model," which is based on the annualized cost of leaving (ACOL) framework. This handbook introduces new users to the ACOL framework and provides some guidelines for choosing reasonable values for the four long-run parameters required to run the Compensation Model: the inflation rate, the rates of real growth in military and private-sector compensation, and the real personal discount rate. The handbook assumes at least a basic knowledge of the AF personnel and active-duty pay systems, the military retirement system, several micro- and macroeconomic principles, present discounted value calculations, and compound growth rates.				
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input checked="" type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL ACSC/EDCC Maxwell AFB AL 36112-5542		22b. TELEPHONE (Include Area Code) (205) 293-2483	22c. OFFICE SYMBOL	

PREFACE

The Personnel Analysis Center of the Directorate of Personnel Plans, Deputy Chief of Staff for Personnel, Headquarters US Air Force (AF/DPAC), provides the Air Force's senior leadership with analyses of the effects of a wide range of current and proposed AF personnel and compensation policies. A fundamental tool DPAC uses in its analyses of compensation policies is an interactive computer program known as the "Compensation Model." This handbook introduces you to the theoretical framework that model is based on and provides some guidelines for choosing reasonable values for the economic parameters required to run the model.

The theoretical foundation of the Compensation Model is the "annualized cost of leaving" (ACOL) framework, which has been published by other researchers. (1:--; 2:--) This handbook integrates their work into a form tailored to your needs as an action officer working in DPAC's hectic environment and using the DPAC model's particular implementation of the ACOL framework.

Effective use of the Compensation Model requires at least a basic knowledge of several different subjects: the AF personnel and active-duty pay systems; the military retirement system; several micro- and macro-economic principles; present discounted value calculations; and compound growth rates. This handbook assumes you meet those prerequisites. In addition, an elementary knowledge of statistics and regression analysis will enhance your appreciation of parts of Chapter Four and of how ACOLs are used in econometric models of personnel retention behavior. Although you don't need any knowledge of computer programming to understand the handbook or to use the model in many applications, some programming experience would increase your understanding of how the model works and would be required in more advanced applications that require changing its FORTRAN code.

The author would like to express his deep appreciation to a number of co-workers who contributed to his understanding of the Compensation Model and of many other analytical aspects of the AF personnel system while he was assigned to DPAC. Ms Patricia Beymer, the lead programmer on the model, spent countless hours explaining its intricacies to him, and Lieutenant Colonel (then Major) Bob O'Ruth provided extensive on-the-job training. Lieutenant Colonel Sal Monaco taught him the art and science of being an action officer, analyst, and supervisor in DPAC; and Major Harvey Greenberg shared with him many ideas on the Compensation Model and on retention modeling in general. Finally, Lieutenant Colonel Ric Katnik, division chief and

CONTINUED

long-time friend, provided several ideas for this project and acted as its sponsor.

This handbook is dedicated with deepest professional respect to Lieutenant Colonel O. Pro his ownself, friend and former commander: "*A nothis noli exedi.*"

ABOUT THE AUTHOR

Major James M. Norris graduated from North Carolina State University with a BS degree in economics and was commissioned through the Air Force Reserve Officer Training Corps. Before entering active duty, he attended graduate school at Vanderbilt University, where he received MA and PhD degrees in economics, specializing in labor economics. His initial active-duty assignment was to the Electronic Systems Division (AF Systems Command) at Hanscom Air Force Base, Massachusetts, where he worked as a procurement staff officer and a contract negotiator for tactical control and navigation (TACAN) systems. After teaching introductory and advanced economics courses at the US Air Force Academy, he served for four years as an analyst and action officer in the Personnel Analysis Center, Directorate of Personnel Plans, Deputy Chief of Staff for Personnel, Headquarters US Air Force (AF/DPAC). In that assignment, he worked on numerous policy analyses concerning how changes in military pay and retirement would affect personnel retention in the Air Force. These projects included extensive work with the DPAC Compensation Model, the subject of this handbook. For part of his final year in DPAC, he was Deputy Chief of the Economic and Behavioral Analysis Division. Major Norris is a distinguished graduate of the Squadron Officer School.

TABLE OF CONTENTS

Preface	iii
About the Author	v
List of Illustrations	viii
CHAPTER ONE--INTRODUCTION	
Purpose and Overview	1
A Brief History of the DPAC Compensation Model	2
CHAPTER TWO--THE PRESENT VALUE OF THE COST OF LEAVING	
Supply of Labor to an Occupation	5
Definition of the Cost of Leaving	7
The PVCOL Model	10
CHAPTER THREE--THE ANNUALIZED COST OF LEAVING	
The ACOL Model	12
The DPAC Implementation of the ACOL Model	23
CHAPTER FOUR--EMPIRICAL ECONOMIC ASSUMPTIONS I: WAGE AND PRICE GROWTH RATES	
The Principles of Real Wage Growth and Relative Wages	27
Making Long-Run Wage Assumptions in Practice	37
CHAPTER FIVE--EMPIRICAL ECONOMIC ASSUMPTIONS II: THE REAL PERSONAL DISCOUNT RATE	
The Importance of the Discount Rate Assumption	41
The Theory of the Personal Discount Rate	42
Empirical Evidence on the Personal Discount Rate	46
CHAPTER SIX--IMPLEMENTING ECONOMIC ASSUMPTIONS IN COMPENSATION MODEL RUNS	
Applying the Long-Term Economic Assumptions	49
Some Related Questions	54
BIBLIOGRAPHY	55

CONTINUED

APPENDICES:

Appendix A--Glossary	60
Appendix B--Example Run	61
INDEX	65

LIST OF ILLUSTRATIONS

TABLES

TABLE 1--Maximum PVCOL vs. Maximum ACOL Values	21
TABLE 2--Changes in Measures of Real Earnings Under the All-Volunteer Force	35
TABLE 3--Present Value of \$1000 Payable After 20 Years of Service	42

FIGURES

FIGURE 1--Probability Distribution of PD(y) ($y_{t,p} = -PD(y)$)	18
--	----

Chapter One

INTRODUCTION

PURPOSE AND OVERVIEW

One of the primary functions of the Personnel Analysis Center (DPAC) is to forecast how changes in military compensation affect the retention patterns of Air Force personnel. Thus, some DPAC analysts devote a substantial portion of their time to developing, modifying, and applying econometric models of AF personnel retention rates. In these models, some measure of relative military and civilian compensation is a key theoretical variable, and the most commonly used measure is the "annualized cost of leaving" (ACOL).¹ (1:13) To compute ACOLs, DPAC currently uses an interactive, multi-option FORTRAN program called the "Compensation Model" or the "ACOL Model," which "allows the analyst to take the place of the 'average' decision maker in each year of service--evaluating each decision point" by computing his or her ACOL.² (12:1-1) This handbook introduces you to two types of information you need to understand in order to use that Model effectively: First, it's necessary to have a basic comprehension of the ACOL Model's theoretical foundations. Second, to run the Model, you must specify a number of economic parameters, and there are several economic principles you should consider in making those assumptions.³

To begin the discussion, the next section of this chapter provides a brief history of the Compensation Model and its application to retention modeling in DPAC. Then, Chapter Two develops the Present Value Cost of Leaving (PVCOL) Model, a theoretical predecessor of ACOL. Next, Chapter Three derives the ACOL measure and discusses its theoretical assumptions and its applications to retention modeling. Chapter Four then discusses the

1. For a discussion of the other models, see the monographs by Arguden and Warner. (1:--; 4:--)

2. Over time, the computer program has taken on the name of its underlying measure, but the conceptual framework that relates retention rates to ACOLs is also called the "ACOL model." To distinguish between the two, this handbook refers to the theoretical model with a lower-case "m" and to the computer program with a capital "M." See also footnote 7.

3. Knowing FORTRAN programming is necessary only for modifying the Model's code, but it might also be helpful in understanding some aspects of running the Model.

rationale for the theoretical relationships among three key economic assumptions necessary for computing ACOL values in practice: the long-term rates of inflation, military wage growth, and civilian wage growth. Chapter Five discusses another key economic assumption, the value of the real discount rate. Finally, Chapter Six describes how to apply these economic assumptions in an actual run of the ACOL Model and how several of the Model's interactive questions are related to each other.

A BRIEF HISTORY OF THE DPAC COMPENSATION MODEL

Econometric models of military personnel retention are a relatively recent phenomenon, dating only from about 1978. (4:1) Two seminal events in the late 1970s seem to have emphasized to the military personnel community the need to model the relationship between retention and its economic determinants. One of those events was the President's Commission on Military Compensation (PCMC); the PCMC's 1978 report recommended reducing military retirement pay for 20-year retirees while permitting early withdrawal of benefits for those who remained on active duty or vesting for those who separated after 10 years' service. The Commission's report wasn't the first proposal for substantially revising the military retirement system, and it seemed likely at the time that it wouldn't be the last. (19:--; 4:1; 10:VII-17 - VII-18 [Table VII-3])

The other watershed in the history of retention modeling was the dramatic decline in both officer and enlisted retention during the late 1970s and early 1980s. The beginning of this "hemorrhage of talent," as it is sometimes called, roughly coincided with three economic developments in the second half of the 1970s: first, civilian employment conditions gradually improved, as reflected by a gradual decline of the civilian unemployment rate; second, Congress and the Administration repeatedly "capped" annual military-pay raises below the amounts required to maintain comparability with the private sector, causing relative military earnings to decline; and third, the capped pay raises also consistently lagged behind inflation in consumer prices, thus reducing military members' purchasing power. The resulting decline in retention, coupled with the likelihood of further attempts to reduce retirement benefits, combined to set the stage for increased attention throughout the military personnel community to developing econometric retention models.

To measure relative military and civilian compensation for its retention models, DPAC adopted the ACOL metric. In 1977, Ms Patricia Beymer, with the assistance of other DPAC analysts, began work on the computer program that came to be known as the Compensation Model.⁴ (15:67,81;

4. The following account is based primarily on the author's personal experience as an analyst in DPAC from June 1982 to July 1986 and on his numerous conversations during that period with Ms Beymer and Lieutenant Colonel S. J. Monaco. Lieutenant Colonel M. W. Simmons and Mr J. J. Harris also provided background information on the model's history. Although the

16:64,69-70; 17:11; 18:14; 21:22) She integrated into the Model some routines that other analysts had already written, at least in part.⁵ The Model was fully operational by early 1982, but Ms Beymer continued to modify and enhance it in response to new requirements until 1984, when she transferred to the Office of Personnel Management. (22:19) Major Harvey Greenberg subsequently made several changes to the Model's standard configuration (known as "MODC7"), and, as of this writing in early 1987, Major Jon Vetterlein is working on some further enhancements. In addition, various other analysts have maintained copies of the Model and modified them for specialized uses or one-time projects, such as experiments with changing the formula for computing retirement pay.

In early 1982, the availability of ACOLs from the Compensation Model allowed Lieutenant Colonel (then Major) S. J. Monaco to develop DPAC's first detailed system of retention equations for Air Force officer and enlisted personnel.⁶ With the retention rates of various subgroups as the dependent variables, he estimated regression coefficients for ACOL and the civilian unemployment rate; for pilots, the number of "new" pilot hires by major airlines was used as an additional measure of job-market pressure. (22:7,16-17,19-20) Combined with the Center's officer and enlisted force-structure simulation models, the Defense Officer Personnel Management System (DOPMS) and the model then called the Enlisted Policy Analysis System (EPAS), these equations gave DPAC the ability to assess in considerable detail how changes in military compensation or general economic conditions would affect the Air Force's retention and force structure. First, the elasticities derived from the regression coefficients are used to forecast changes in retention rates as a result of changes in the explanatory variables. Using these forecasted retention rates, DOPMS and EPOM can then produce detailed, year-by-year forecasts of how the initial change in compensation policy or economic conditions will affect the force structure.⁷ Since 1982 several improve-

official unit histories don't include the names of any analysts who worked on the Model, they do confirm the chronology.

5. Hence, the same variable often has different names in different sub-routines.

6. Previously, analysts had used "commonly accepted elasticities" that had not been developed in DPAC and that were not available for the detailed demographic categories required by the Center's force-structure simulation models. (20:8; 21:5)

7. A final caveat on terminology: Many analysts outside DPAC, for example those in the Office of the Assistant Secretary of Defense for Force Management and Personnel, refer to the entire process--from computing the changes in ACOLs to the changes in the force structure--as the "ACOL Model." But within DPAC, this term is usually understood to refer primarily to computing the ACOLs themselves (and sometimes the consequent changes in retention rates as well). In discussions with analysts from outside the Center, it's advisable to ensure that everyone understands the terminology being used.

ments have been made to automate the interface between the Compensation Model and the force-structure simulation models, but the basic analytical process just described remains unchanged.

Chapter Two

THE PRESENT VALUE OF THE COST OF LEAVING

The Compensation Model computes a service member's Annualized Cost of Leaving (ACOL) and a related value, his Present Value of the Cost of Leaving (PVCOL). Chapter One outlined how these measures can be used to analyze the expected effects of alternative military compensation policies on personnel retention, and the first section of this chapter briefly discusses retention modeling in the more general context of the supply of labor to an occupation.

Fundamentally, ACOL and PVCOL are both just possible measures of the opportunity cost of leaving the service now instead of remaining in until some point in the future and then leaving. This intuitive interpretation is relatively simple, but you will be able to apply the Compensation Model to policy analyses more effectively if you understand at least the principles of ACOL's mathematical derivation and of the theoretical framework that relates ACOL to a member's stay-or-leave decision. DPAC's retention models are based on ACOL, but that measure is derived from PVCOL, which this chapter will develop.

Arguden's derivation of the ACOL and PVCOL models is more general and more complex than Warner's. (1:150-152,154-157; 4:3-15) This chapter and the next one attempt to give a more intuitive formulation than either of those authors does by combining parts of their approaches, at the sacrifice of some mathematical rigor and detail. The interested reader may wish to consult their papers for a more technical treatment of these models and their alternatives.

SUPPLY OF LABOR TO AN OCCUPATION

Determinants of Labor Supply

Modeling retention behavior is an application of the economic theory of the supply of labor to an occupation. That labor supply is determined by a combination of the occupation's pecuniary and nonpecuniary characteristics. The pecuniary determinants consist of the expected earnings in one occupation relative to those in the next-best alternative; here, earnings include the monetary value of all income supplements (or "fringe benefits"), such as retirement pay. In the case of military retention, the relevant pecuniary comparison is between military and civilian compensation. The nonpecuniary determinants may be thought of as falling into three categories: (1) taste or distaste for an occupation; (2) friction in the operation of the labor

market, such as lack of complete information about an occupation's monetary and nonmonetary characteristics; and (3) random shocks, such as a family illness that limits one's geographic mobility.¹ (1:13-14; 3:92)

Relative Earnings and the Career Path

To evaluate relative earnings, the PVCOL and ACOL models take a human-capital approach to the retention, or labor-supply, decision. That is, they assume that the AF member seeks to maximize his or her satisfaction based on an earnings measure that takes into account the present discounted value of the expected income streams from the two possible sets of future career paths he or she faces. One possible path is that the person remains in the AF until he or she is eligible for retirement. His or her lifestream earnings then consist of three components: active-duty pay (including any bonuses or special pays) from the decision point in question through the retirement point, military retirement pay, and earnings from any post-service career.² On the other hand, if the member separates before retirement eligibility, then the earnings stream consists of two parts: active-duty pay from the decision point in question through the separation point, and the earnings from any post-separation career.

A Qualification: Retention Patterns

Before deriving the PVCOL measure, two important points about retention-rate patterns need to be discussed, because any model of retention behavior must take them into account in order to avoid spurious correlations or misleading results.³ The first point, as described by Warner, is that

. . . there should be a natural tendency for retention rates to rise with term of service (t). This tendency is separate and distinct from any increase in the financial incentive to stay and is due to the fact that in early terms of service the retention decision-making process serves to sort out those who like military service from those who don't. As this sorting process proceeds, the cohorts of personnel who stay will . . . [consist of] people who, on

1. The literature contains many such sets of determinants. This hybrid list is useful for understanding ACOL in the more general context of occupational-choice models and for seeing some of its limitations. Furthermore, these categories of nonpecuniary effects aren't necessarily mutually exclusive; e.g., a family illness could be interpreted as creating a distaste for relocating, which could be offset by relative earnings that were sufficiently high.

2. Note that this treatment omits any income from Social Security and from any retirement pay earned from post-service employment.

3. Since a cohort's loss rate equals 1 minus its retention rate, this and all subsequent discussions and models could be reformulated in terms of loss rates.

average, have a higher taste for military service and hence higher retention rates.⁴ (4:3)

The second point is that the retention rate for YOS t may depend on past pay policies as well as expected future ones. Using Warner's example,

. . . suppose one group of first-term reenlistees receives a reenlistment bonus and a second (otherwise identical) group does not. The first-term reenlistment rate of the group receiving the bonus should be higher. However, at the second-term reenlistment point, the group receiving the first-term bonus may have a lower reenlistment rate (assuming both groups face the same future military and civilian pay streams). This is because the group receiving the first-term bonus has a lower average taste for service at the second-term point than the group not receiving the bonus. (4:3)

Note that the same caveats also apply to the relationship between retention and other explanatory variables. For example, cohorts completing terms of service in the mid-to-late 1980s enlisted or reenlisted during the high-unemployment years of the early 1980s. Thus, other things being equal, these cohorts' average tastes for service may be lower than those who entered the AF in earlier or later years, when the unemployment rate was lower.

With the labor-supply framework and these caveats in mind, let's turn now to a formal definition of the PVCOL measure. Later, we'll return to the important operational issue of what measures we use for the necessary income streams.

DEFINITION OF THE COST OF LEAVING

Conventions

Consider an Air Force member who has just completed t years of service (YOS). This member must decide whether to leave the service now, or stay one more year and then leave, or stay two more years and then leave, etc.⁵ If T is the total number of years of possible service, then the member faces

4. Warner's discussion uses term of service, but the same reasoning applies to years of service, which is used in this handbook for generality. See the following footnote.

5. In any given year, some members have service commitments outstanding and thus aren't eligible to separate, regardless of their ACOL values. To account for this restriction, the enlisted-force policy-analysis model (EPOM) uses regression coefficients fit to loss rates that are percentages of those eligible to separate in a given YOS, rather than of the total population in that YOS. EPOM applies the loss rates it forecasts to only the separation-eligible population in the years being simulated. But the officer model (DOPMS) doesn't currently account for this restriction

T-t possible future decision points (or horizons of service) and corresponding streams of income, in addition to the possibility of separating now, after YOS t.⁶ To simplify the present-value computations, assume the member receives all income in a lump sum at the end of any given year.

Further, let the year of service just completed be the reference point for present-value computations; i.e., all incomes will be discounted back to "now," the end of YOS t. This convention has two advantages: First, it slightly simplifies the exponents in all discounted terms, and second, it corresponds to our paradigm that the stay-leave decision is being made at the end of YOS t.⁷

Return to Staying

Define the following variables:

M_j = active-duty military pay during YOS j ;

R_n = the present value at the end of YOS n of future retirement benefits (if any) vested after completing n years of service;

W_n = the present value at the end of YOS n of civilian compensation earned after YOS n ;

directly. Instead, it uses regression coefficients fit to gross loss rates, i.e., losses as a percentage of the total population in any YOS, both separation-eligible and -ineligible. Its forecasted loss rates are then applied to the total population, by YOS, for future years.

6. Think of T as the high year of tenure for the maximum pay grade the member achieves--e.g., under current Air Force policy, 30 YOS for an O-6, 28 for an O-5, etc.

7. Note, however, that the Compensation Model uses the convention of discounting to YOS $t+1$, the end of the upcoming year, since that's the next time income will be received. (12:5-12) Although this author prefers using YOS t to correspond with the timing of the decision point, the essential matter is to use the same convention consistently, whichever one is chosen. Because it is a convention, the reference point for discounting is to some extent arbitrary. The sets of ACOLs (and PVCOLs) resulting from the two different conventions would differ from each other by a constant factor B (defined in the next section). In terms of fitting a regression, this should be no different theoretically than expressing the cost of leaving in, say, 1968 dollars instead of in 1967 ones. (As Chapters Three and Six explain, ACOLs must be expressed in constant dollars when regressing them against retention data from different fiscal years.)

B = a constant discounting or present value factor, $1/(1+d)$, where d is the member's real personal discount rate, or rate of time preference in YOS t .⁸

The present value of the member's income from staying in the service from the end of YOS t through YOS n is thus⁹

$$S_{t,n} = \left[\sum_{j=t+1}^n M_j B^{j-t} \right] + (R_n + W_n) B^{n-t}, \quad (2-1)$$

where each term is discounted back to the end of the year just completed, YOS t . That is, at the end of YOS t , the present value of the income received from staying in the service from that time through the end of YOS n consists of the discounted value of three income streams: (1) M , the stream of active-duty military pay from YOS $t+1$ through the end of YOS n ; (2) R , the stream of military retirement pay the member would receive (if eligible for any) from waiting until the end of YOS n to leave, and (3) W , the stream of earnings from a post-service civilian career that begins in year $n+1$. Note again that, because we assume all income is received at the end of a year, the next possible receipt of any component of income in Equation 2-1 will occur one year hence, at the end of year $t+1$. Thus, each component

8. Chapter 5 discusses the possibility that d varies with t (but not with j).

9. The derivation shown here follows the one in Warner's seminal work. (4:4-5) However, the definition of $S_{t,n}$ in his Equation 1a contains several confusing points. First, it's not clear which terms the summation operator applies to; as the brackets in Equation 2-1 above show, the summation applies only to the first term. Second, the coefficient of $[R_n + W_n]$ contains an apparent typographical error: The exponent of beta should be $n-t$, not $j-t$. (The repetition of Warner's Equation 1a on his page 9 shows the correct exponent.) The intent is (apparently) to discount $[R_n + W_n]$, which is a constant already discounted to YOS n , back to the end of YOS t . This raises a third point of confusion: As shown by the exponents on their respective discounting factors, the two terms in Warner's Equation 1a appear to be discounted to different years--the first term to $t+1$, the second to t . Clearly, both terms must be discounted to the same point; we have chosen the end of the current year, YOS t , which the context of Warner's discussion tends to suggest. For example, consider the first year of the summation, $j=t+1$. Since by our assumption the military pay M_j isn't received until the end of the year, it must be discounted one year, back to YOS t ; i.e., the exponent of B must equal 1 for YOS $t+1$. This requires that the exponent be $j-t$ in general, as shown in Equation 2-1. Arguden's formulation, while more general and more complex, confirms these points. (1:154) Unfortunately, Warner doesn't specify his convention for when income is received. The discounting scheme in his Equation 1a would be consistent with assuming military pay is received at the beginning of each year, while all other income is received at the end of the year.

must be discounted at least one year, to the end of year t , the point at which the stay-or-leave decision is being contemplated. (R and W have already been discounted to the end of year n .)

Return to Leaving

The present value of the income stream from leaving now, L_t , has two components:

W_t = the present value of the stream of future civilian income the member would receive by leaving now, and

R_t = the present value of any military retirement benefits that are already vested.

Therefore,

$$L_t = W_t + R_t . \quad (2-2)$$

The Cost of Leaving

The pecuniary cost to the member of leaving the service after YOS t rather than staying through YOS n is defined as the amount of pecuniary income the member would forgo by doing so. Thus, the present value of the cost of leaving after YOS t instead of after YOS n , $PVCOL_{t,n}$, is

$$PVCOL_{t,n} = S_{t,n} - L_t , \quad (2-3)$$

or, combining Equations 2-1 and 2-2,

$$PVCOL_{t,n} = \left[\sum_{j=t+1}^n M_j B^{j-t} \right] + (R_n + W_n) B^{n-t} - W_t - R_t . \quad (2-4)$$

Note that $PVCOL_{t,n}$ may be positive, zero, or negative, and that there are $T-t$ possible values of $PVCOL_{t,n}$ (i.e., for $n = t+1, t+2, \dots, T$). The cost of leaving may also be interpreted as the (net) return to staying.

THE PVCOL MODEL

Definition

The PVCOL is one possible measure of relative military and civilian compensation that could be used as an explanatory variable in a regression model of retention behavior. Assume that the member behaves as though he has computed the values of $PVCOL_{t,n}$ for all $T-t$ possible future periods of service and bases his decision on the maximum of the $T-t$ possible costs of

leaving.¹⁰ Therefore, $PVCOL_{t,n}$ "represents the opportunity cost of leaving now rather than staying in for the highest future income stream to be had by additional military service."¹¹ (4:5) The maximum PVCOL value could thus be used as a proxy for relative compensation in a regression of retention rates as a function of compensation and other explanatory variables.

Disadvantages

The PVCOL model has several disadvantages. First, it doesn't consider the nonpecuniary determinants of the retention decision, such as taste for service, so it can't explain why two persons with equal costs of leaving might make different stay-leave decisions. This also means it doesn't take into account the self-selection decisions made in previous years. (4:3-4,6-7) Second, and related to the first, this model is "forward-looking" only: The member's retention decision in YOS t is related to the future pay streams he expects and doesn't consider the effects of past pay policies. Third, as mentioned above, the choice of the maximum PVCOL as the relevant regressor is ad hoc rather than derived from a theory of consumer choice. Fourth, because PVCOL is a maximum-regret model, compensation policy changes that don't affect "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."¹² (1:21)

10. The literature gives no rationale for assuming the member uses the maximum PVCOL value, but we may draw a rough, ad hoc justification from the intuitive interpretation of the ACOL model given in Chapter Three under "ACOL and the Stay-Leave Decision."

11. As a result, the PVCOL model is sometimes referred to as a "maximum-regret" model. (1:16,20) It could also be thought of as a "maximum-return" model, because each $PVCOL_{t,n}$ represents the income differential earned by staying in the service through YOS n .

12. As discussed on page 17, such terminology as "the optimal time to leave" is potentially misleading.

Chapter Three

THE ANNUALIZED COST OF LEAVING

THE ACOL MODEL

The Taste for Service

Unlike the PVCOL model, the ACOL model explicitly recognizes that individuals differ considerably in their tastes for military service. (1:154; 4:7) We can indirectly measure an individual's taste for service through the military-civilian compensation differential that would make him indifferent between military and civilian life. Let

$y_{t,p}$ = the annual monetary equivalent of person P 's taste for military service, net of his taste for civilian life, as he evaluates it in YOS t ;¹

$PD(y)$ = the discounted annual pay differential in YOS t required to make person P indifferent between military and civilian life; this pay differential is a function of $y_{t,p}$, that is, $PD_{t,p}(y_{t,p})$; however, for simplicity in notation, abbreviate this expression as shown, with the understanding that it applies to person P in YOS t ;

PD_a = the annual military-civilian compensation differential person P expects to actually receive, based on his evaluation of his $PVCOL_{t,n}$ (which of the $T-t$ values of $PVCOL_{t,n}$ he chooses and how he annualizes it will be addressed below).

We can distinguish three cases of taste for service, depending on whether $PD(y)$ is negative, zero, or positive:

Positive Taste for Service: $PD(y) < 0$. Although the direction of this inequality may initially seem reversed, it's not. If $PD(y) < 0$, the member would be indifferent between military and civilian life even if the present value of his expected earnings from military service were less than those

1. A member's military occupation may affect his taste for service; e.g., someone with adverse working conditions is likely to have a negative value of $y_{t,p}$.

from civilian life by the amount $PD(y)$. Hence, this member may be said to have a positive taste for service, and its monetary equivalent is

$$y_{t,p} = -PD_{t,p}(y_{t,p}) > 0 . \quad (3-1)$$

Note the negative sign in Equation 3-1: since $PD(y)$ is negative, the taste measure $y_{t,p}$ is positive.²

Neutral Taste for Service: $PD(y) = 0$. In this case, the member is indifferent between military and civilian life only if his expected compensation differential is zero:

$$y_{t,p} = -PD_{t,p}(y_{t,p}) = 0 . \quad (3-2)$$

Negative Taste for Service: $PD(y) > 0$. Here, in order to make the member indifferent, some positive pecuniary return is necessary to overcome a distaste for military service. Thus,

$$y_{t,p} = -PD_{t,p}(y_{t,p}) < 0 . \quad (3-3)$$

Again, note the negative sign: since $PD(y)$ is positive in this case, the taste measure is negative.

The Retention Decision and Taste for Service

It is important to recognize that the stay-leave decision of an economically rational member should depend only on the comparison of his expected pay differential to his taste factor, not on the sign of his taste factor. Presumably, having taken into account both the pecuniary and nonpecuniary returns associated with military life, a member would desire to continue in service as long as, for at least one planning horizon,

$$PD(y) < PD_a , \quad (3-4A)$$

even if $PD_a < 0$. That is, we assume the member would want to remain in the service as long as his expected income differential for at least one planning horizon exceeds the pay differential that would make him indifferent between staying and leaving, even if he expected a negative pay differential (this would require that $PD(y) < 0$ as well, as Equation 3-4A implies). (Any excess of PD_a over $PD(y)$ is an economic rent to the member.) But if $PD(y) > PD_a$, the member has a net incentive to leave the service, even if $PD_a > 0$. As Equation 3-4A makes clear, this means that whether the member's taste for service, $y_{t,p}$ ($= -PD(y)$), is positive or negative doesn't by itself affect his retention decision.

2. Caveat: Everyday connotations make this terminology potentially ambiguous. As used here, "taste for service" is a general expression requiring an algebraic sign in order to indicate the direction of the member's preferences. While "distaste" clearly implies $y_{t,p} < 0$, "taste for service" doesn't necessarily imply $y_{t,p} > 0$, despite its everyday connotation.

Conceptually, then, $PD(y)$ is a benchmark that a member compares his expected military-civilian pay differential to in considering his stay-leave decision; $y_{t,p}$, which equals the negative of $PD(y)$, is the monetary equivalent of the net annual nonpecuniary returns the member associates with military service. The DPAC Compensation Model assumes that $y_{t,p}$ is a constant, i.e., that person P 's taste for service is fixed and doesn't change for any future term of service t .

Derivation of ACOL

Equation 3-4A stated our assumption that a member would prefer to remain in the service if $PD(y) < PD_a$ for at least one planning horizon. Substituting for $PD(y)$ and rearranging terms, we have

$$-PD_a < y_{t,p} \quad (3-4B)$$

where PD_a is the annualized value of one of the $T-t$ values of $PVCOL_{t,n}$. Since the taste measure's monetary equivalent $y_{t,p}$ is an annualized value, it has a present value over the next n periods of

$$Y_{t,p} = \sum_{j=t+1}^n y_{t,p} B^{j-t} \quad (3-5)$$

Furthermore, recall that PD_a is just the annualized value of the $PVCOL$ value, say $PVCOL_{t,n^{\wedge}}$, for one of the member's planning horizons n^{\wedge} . Hence, we can restate Equation 3-4B in present-value terms and say that a member would choose to remain in the service if there is at least one period of future service n^{\wedge} over which

$$-PVCOL_{t,n^{\wedge}} < Y_{t,p} \quad (3-6A)$$

or

$$-PVCOL_{t,n^{\wedge}} < \sum_{j=t+1}^{n^{\wedge}} y_{t,p} B^{j-t} \quad (3-6B)$$

Since the negative of the cost of leaving is just the return to leaving, this condition says that a member would choose to stay in the AF if there exists at least one period of future service over which, in present-value terms, the monetary equivalent of his taste factor exceeds the return to leaving.

By assumption, $y_{t,p}$ is a constant, so we can bring it outside the summation operator; then, dividing both sides by the summation term yields

$$-\frac{PVCOL_{t,n^{\wedge}}}{\sum_{j=t+1}^{n^{\wedge}} B^{j-t}} < y_{t,p} \quad (3-7)$$

Ignore the negative sign in Equation 3-7 for the moment. (As we've seen, it's related to the negative sign in Equations 3-1 - 3-3.) The summation term in the denominator is just a present value of annuity factor, or the present value of an annuity of \$1 per payment period for n periods.³ Since $PVCOL_{t,n}$ is the present value of a stream of payments (usually not annuities, or equal payments, here), dividing by the present value annuity factor annualizes $PVCOL_{t,n}$. This tells us the value of an annuity that the amount $PVCOL_{t,n}$ would fund for n years, given a constant interest rate d . (Recall that $B = 1/(1+d)$.) So, ignoring the negative sign, the fraction in Equation 3-7 tells us the annual payment that has a present value of $PVCOL_{t,n}$ when paid over n years. We define the value of this annual payment, or annuity, as the annualized cost of leaving the service after YOS t instead of after YOS n , or $ACOL_{t,n}$. In general, for each planning horizon n , where $n = t+1, t+2, \dots, t$,

$$ACOL_{t,n} = \frac{PVCOL_{t,n}}{\sum_{j=t+1}^n B^{j-t}} \quad (3-8)$$

Meaning of an ACOL

It is important to understand the precise meaning of an ACOL value. For simplicity, assume that $PVCOL_{t,n}$ is positive; hence, $ACOL_{t,n}$ will also be positive. If member P left the service now (after YOS t) instead of after YOS n , the present value of his lifestream earnings would be less than it otherwise would have been by the amount $PVCOL_{t,n}$. This would be equivalent to forgoing an income of $ACOL_{t,n}$ each year for the next $n-t$ years (not for the rest of his life, as $ACOL_{t,n}$ is sometimes misinterpreted). Put another way, this member would have to receive an annuity equal to $ACOL_{t,n}$ in each of the next $n-t$ years, in addition to his civilian earnings, in order to bring the present discounted value of his lifestream income up to what it would have been had he remained in the service through YOS n .

3. An annuity is a fixed dollar amount paid or received (e.g., a mortgage payment or retirement pay, respectively) over a given period of time m . The present value of a stream of such equal periodic payments (A) is

$$PV = A \times PVAF,$$

where $PVAF$, or the present-value annuity factor for the period m , is the sum of the present-value factors, $1/(1+d)^k$, for periods $k = 1, 2, \dots, m$. Thus, the annuity $A = PV / PVAF$, which has the same form as Equation 3-8. For more complete coverage of annuity formulas, see a text on the mathematics of finance; Clayton and Spivey give an excellent basic treatment. (2:41-42, 87-88)

ACOL and the Stay-Leave Decision

We have now derived, more or less formally, $ACOL_{t,n}$ as one possible measure of a concept we've been using intuitively throughout this section: PD_a , the annual military-civilian compensation differential that person P expects to actually receive, based on his evaluation of his $T-t$ values of $PVCOL_{t,n}$. Assume again that the member behaves as though he has computed the values of $ACOL_{t,n}$ for all $T-t$ possible future periods of service. Thus, restating the stay-leave decision (Equation 3-4A) in terms of $ACOL$ instead of PD_a , a member would desire to continue in service only if there is at least one horizon of service n for which

$$PD(y) < ACOL_{t,n} \quad (3-4C)$$

even if $ACOL_{t,n} < 0$. That is, we assume the member would want to remain in the service as long as his expected income differential for at least one planning horizon exceeded the pay differential that would make him indifferent between staying and leaving, even if his $ACOL$ were negative.⁴ Substituting for $PD(y)$, we can also express Equation 3-4C as

$$-t_{t,p} < ACOL_{t,n} \quad (3-4D)$$

although this form has no clear intuitive interpretation. (Equation 3-4D is equivalent to Equation 3-7.)

The Maximum ACOL Assumption

Having derived the decision rule in Equation 3-4C, we can finally answer the question of which one of the $T-t$ values of $ACOL_{t,n}$ we assume is the relevant one to use in explaining the actual stay-leave decisions of service members. Restating the question in terms of retention modeling, which one of the $ACOL$ values is to be used as the explanatory compensation variable in fitting a regression equation to retention data? The $ACOL$ model assumes that the maximum value of $ACOL_{t,n}$ is the appropriate one to use.⁵ Call this value $ACOL^*$. (Note that if any value of $ACOL_{t,n}$ satisfies Equations 3-4C and 3-4D, then the maximum value $ACOL^*$ also does.)

For many analysts, this assumption is the most difficult aspect of the $ACOL$ model to understand. To some, choosing the maximum value may initially seem appealing, even obvious, because many of the problems we deal with as quantitative analysts involve optimizing some objective function (i.e., finding its maximum or minimum value). But then an intuitive problem

4. It is a useful exercise to demonstrate that Equation 3-4C is valid whatever the sign of the taste for service, $y_t (= -PD(y))$.

5. Note that the maximum of the $PVCOL_{t,n}$ values does not, when annualized over the appropriate number of periods, yield the maximum of the $ACOL_{t,n}$ values. This is illustrated later in the section "Some Properties of $ACOL$," pages 20-21.

arises. Consider the following: The member's value of $PD(y)$, the annual pay differential required to make him indifferent between military and civilian life, is the critical threshold in his stay-leave decision. If there are values of $ACOL_{t,n}$ other than $ACOL^*$ that satisfy Equation 3-4C, even the minimum of those would provide the required financial incentive to stay in the service. Why, then, choose as a regressor the maximum $ACOL$, which is greater than $PD(y)$ by an essentially arbitrary amount?

Another source of potential confusion is that the literature has concentrated on the mathematical derivation of the model, leaving the intuitive interpretation to the reader. Unfortunately, this may result in intuitive misinterpretation! For example, the terminology used to express and interpret the model has become misleading or ambiguous in some cases: even Arguden refers to the maximum $ACOL$ value as "which of the future decision points is the best to leave . . ." (1:154, emphasis added) That phrase seems to directly contradict the concept of the maximum cost of leaving. Wouldn't a member considering leaving want to minimize the cost (i.e., maximize the return) of doing so? Indeed, why would any economically rational member decide to separate when the annualized cost of doing so is its maximum? The very idea of using the maximum $ACOL$ seems fraught with potential confusion and contradiction.

Both of these perplexing aspects of the maximum- $ACOL$ criterion appear to stem from an old logical pitfall, the fallacy of composition, i.e., the assumption that what's true for the individual or part is also true for the group or whole, and vice versa. The derivation of the decision criterion in Equation 3-4C is straightforward and perhaps most easily understood in terms of an individual or an average decision maker. This was the approach taken above. However, to apply the $ACOL$ criterion to explaining observed patterns of retention decisions requires that we think in terms of the cohort making those decisions, not of the individual.⁶ In practice, we can't determine the value of $PD(y)$ unique to an individual member, nor is it possible to compute an $ACOL$ for each one. Therefore, we can't apply Equation 3-4C to members individually. But we can compute the expected value of $ACOL_{t,n}$ for the average member of the cohort for each planning horizon n , as will be described later.

For the cohort of members completing YOS t , let $f_t[PD(y)]$ be the probability density function giving the distribution of $PD_{t,p}(y_{t,p})$ among them. Consider the distribution of $PD(y)$ shown in Figure 1, where $ACOL^*$ is the expected value of the maximum $ACOL$ for the cohort's average member.⁷ Given this $ACOL$, we would observe from actual retention behavior that some members

6. In both Arguden and Warner, the transition from deriving the individual's $ACOL$ to its application to the cohort's distribution of tastes for service is abrupt and without warning about its implications for these types of questions. (1:154-155; 4:8)

7. For purposes of this discussion, the shape and mean of the distribution are completely arbitrary, as is the location of the origin. Figure 1 shows a symmetric distribution because empirical applications of the $ACOL$

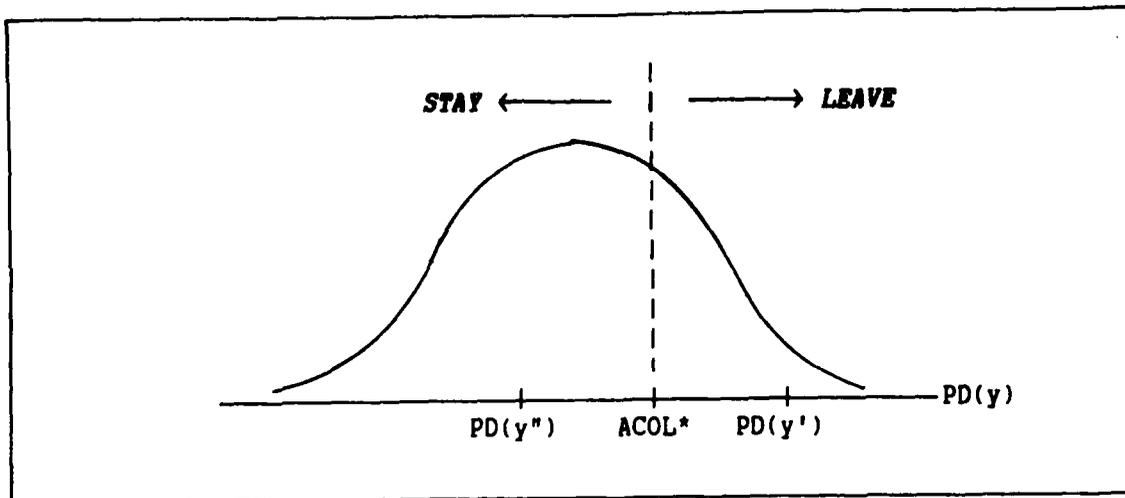


Figure 1. Probability Distribution of $PD(y)$
 ($Y_{t,p} = -PD(y)$)

would choose to leave the service, while the rest would elect to remain.⁸ By assumption, then, those who choose to separate must have tastes for service y' such that $ACOL^* < PD(y')$, while those who stay in must have tastes y'' such that $PD(y'') < ACOL^*$.⁹ In other words, given $ACOL^*$, the maximum of the expected $ACOL_{t,n}$ values, some members would still prefer to separate from the service, despite the "high" forgone earnings this would entail, because their distaste for service means they require a pay differential $PD(y')$ even greater than $ACOL^*$ just to make them indifferent to military life. Thus, for any observed retention pattern, the corresponding $ACOL^*$ that we compute must be the threshold value separating the stayers from the leavers. That is why we choose $ACOL^*$ as the proxy for relative compensation in our econometric model of retention rates.

model typically assume that tastes have a logistic distribution, which is symmetric about its mean. (1:155; 4:9)

8. Caveat: The distribution in Figure 1 is the arithmetic inverse of the distribution in Arguden's Figure 1, since he graphs the distribution of $Y_{t,p}$, the negative of $PD(y)$. (1:29) Thus, the "Stay" and "Leave" labels are reversed between his figure and the one above.

9. If $PD(y) = ACOL^*$ for a person, he would be the marginal member, who is indifferent between staying and leaving, given his taste for service, his discount rate, and the current and expected compensation systems.

Note that taste for service no longer appears explicitly in the model, although it appeared in the model's stay-leave decision criterion, Equation 3-4C. Instead, taste is now implicit in the model: ACOL* divides those who are willing to stay, having compared ACOL* to the monetary equivalent of their tastes for service, from those who choose to separate. But each value of $ACOL_{t,n}$ is itself independent of tastes.

Given the maximum ACOL value ACOL* and the probability distribution of tastes for service $f_t[PD(y)]$, the expected retention rate for the cohort completing YOS t is just

$$r_t = \int_{-\infty}^{ACOL^*} f_t[PD(y)] dPD(y) \quad (3-9)$$

This equation confirms our intuitive notion that the retention rate should increase as ACOL* increases. (1:154-155; 4:8)

Some Properties of the ACOL Measure

A Property of the Maximum ACOL. By introducing the taste parameter $y_{t,p}$ into the equation for PVCOL, we can demonstrate an important property of the ACOL measure. Recall from Equation 2-4 that the present value of the pecuniary cost of leaving after YOS t instead of after some future YOS n is

$$PVCOL_{t,n} = \left[\sum_{j=t+1}^n M_j B^{j-t} \right] + (R_n + W_n) B^{n-t} - W_t - R_t \quad (2-4)$$

Define a new measure of the cost of leaving including the member's taste for service:

$$PVCOLY_{t,n}(y_{t,p}) = \left[\sum_{j=t+1}^n (M_j + y_{t,p}) B^{j-t} \right] + (R_n + W_n) B^{n-t} - W_t - R_t \quad (3-10)$$

where $y_{t,p}$ is the monetary equivalent of member P's tastes and is a constant for any given member. In addition, recall from Equation 3-1 that

$$PD(y) = -y_{t,p} \cdot$$

Let ACOL' be that value of ACOL such that

$$ACOL' = PD(y) \quad (3-11A)$$

or

$$y_{t,p} = -ACOL' \quad (3-11B)$$

By substituting $-ACOL'$ for $y_{t,p}$ in Equation 3-10, it can be shown that $PVCOLY_{t,n}(-ACOL') = 0$.¹⁰ That is, for that ACOL value at which the member is indifferent between staying in the service or leaving it, his net cost of leaving is zero.¹¹ For any member, there is some theoretical ACOL value at which this condition holds. For the marginal member of the cohort, for whom $y_{t,p} = -ACOL^*$, it would thus hold that $PVCOLY_{t,n}(-ACOL^*) = 0$.¹²

Maximum PVCOL vs. Maximum ACOL Values. A second property of ACOL is that the maximum of the $PVCOL_{t,n}$ values, annualized over the appropriate number of periods, does not yield $ACOL^*$, the maximum of the $ACOL_{t,n}$ values. A simple example, based on one shown by Arguden, illustrates this property. (1:24-25) Assume that the discount rate d is zero, and let the present value of staying in the military and then leaving ($S_{t,n}$ from Equation 2-1) at YOS 4, 8, 20, and 24 be as shown in the second column of Table 1. The third and fourth columns show the PVCOL and ACOL values for the member as he would see them if he were at the end of YOS 4.¹³ In this example, the maximum PVCOL, as viewed by the member at YOS 4, is \$32, which occurs at YOS 20; but the maximum ACOL is \$2.25, occurring at YOS 8.

Non-Homogeneity. If military and private-sector pay were both to increase by the same proportion, then their ratio would be unchanged. To the extent that retirement pay in both sectors is proportional to pay before retirement, the ratio of lifetime earnings for a given career path should also not be affected by such a proportional increase in wages. This might seem to imply that retention wouldn't change, other things being equal. But

10. Note that only by chance would $ACOL'$ equal any of the $T-t$ discrete values of $ACOL_{t,n}$ for an individual member. The $ACOL_{t,n}$ are expected values, whether for an individual member or a cohort of members, and are independent of tastes. Since $ACOL'$ depends on member P 's individual taste for service, it may fall between two values of $ACOL_{t,n}$, or it may be less than or greater than all of them.

11. Proof of this property is straightforward but slightly tedious because of the summation operators. To save space, it will only be sketched here. After making the substitution noted, the expression within the summation is $(M_j - ACOL')B^{j-t}$. Multiply this term out, distribute the summation operator over the two terms, and regroup terms. Part of the resulting expression is just $\sum (ACOL')B^{j-t}$. The remaining terms combine to equal $PVCOL_{t,n}$ (Equation 2-4), which is a constant. Since $ACOL'$ is also a constant, it can be brought outside the summation operator in the other term. Then substitute from Equation 3-8 for $ACOL'$ and cancel the $\sum B^{j-t}$ terms, leaving $PVCOL_{t,n} - PVCOL_{t,n} = 0$.

12. Caveat: $PVCOLY_{t,n}(-ACOL') = 0$ for any ACOL value that satisfies Equation 3-11B. This property does not imply that the maximum ACOL always makes the net cost of leaving zero, as Warner's discussion might incorrectly be thought to mean. (4:9)

13. Table 1 employs a recursive property of PVCOL for computing the values of $PVCOL_{4,n}$: It can be shown that $PVCOL_{n,n+k} = S_{t,n+k} - S_{t,n}$.

<u>n</u>	<u>S_{t,n}</u>	<u>PVCOL_{4,n}</u>	<u>ACOL_{4,n}</u>
4	\$10	-	-
8	19	\$ 9*	\$2.25**
20	42	32	2.00
24	40	30	1.50

*PVCOL_{4,n} = \$19-\$10, \$42-\$10, etc.

** ACOL_{4,n} = (\$19-\$10)/(8-4), (\$42-\$10)/(20-4), etc.

Table 1. Maximum PVCOL vs. Maximum ACOL Values

PVCOL_{t,n} (Equation 2-4) and ACOL_{t,n} are defined by absolute differences in pay streams, not by relative ones. Thus, other factors remaining the same, the higher the rate of growth in real pay, the greater PVCOL and ACOL would become, even if real military and civilian pay were to grow at the same rate between two periods. (Essentially, the absolute difference between any given military and civilian earnings streams would increase in algebraic value.) This in turn implies an increase in retention, since the higher maximum ACOL value should exceed the threshold pay differentials PD(y) of more members than the previous value of ACOL* did.¹⁴

Disadvantages of the ACOL Model

As a theoretical framework for analyzing retention behavior, the ACOL model remedies two of PVCOL's deficiencies: first, it implicitly allows for variation in taste for service among members; and second, using the maximum ACOL value as a regressor to explain retention behavior is derived from the theory of consumer choice, not specified ad hoc. However, the model still has some disadvantageous properties.

Forward-Looking. As in the PVCOL model, the member's retention decision in YOS t is related only to expected future pay streams and doesn't take into account the effects of pay policies in prior years.

14. Arguden and Warner both discuss several additional properties of the ACOL model, given the specific assumption that tastes for service have a logistic distribution. (1:155-157; 4:10-15) The interested reader should consult their monographs.

Self-Selection. Although the ACOL model allows tastes to vary among service members, it can't predict the truncation of the taste distribution that occurs over time as those who have greater tastes for service tend to stay in, while the others tend to leave. This causes an internal inconsistency in the model's assumptions as it is usually applied: We assume each member's tastes are constant over time. But when we estimate the parameters of our model of retention behavior as a function of ACOL, we must also assume that the distribution of all members' tastes for service has a constant mean and variance over time. This implies that the tastes of those members who remain in the service must change at each decision point in such a way as to maintain their cohort's previous taste distribution; otherwise, that distribution would change as those with greater distaste for service separate. "This assumption breaks the link between compensation policies in one period and retention rates in the next." (1:26)

There are two possible ad hoc adjustments to the model to remedy this problem. One is to attempt to capture the correlation between the mean of the taste distribution and years of service by adding a variable for YOS to the regression model. But,

. . . 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. (1:27)

The other method, which DPAC's retention models use, is to run separate regressions for each YOS or for groups of several YOSs. This method suffers essentially the same disadvantages as the previous one.

Maximum Regret. Like PVCOL, ACOL is also a maximum-regret model. Therefore, the model would predict changes in retention behavior as a result of changes in compensation policy only if those policies affected either the value of the maximum ACOL or the YOS in which it occurs. (4:9-10) In practice, this property means that changes in Selective Reenlistment Bonuses (SRBs) may have no effect on the maximum ACOL value, hence none on forecasted retention, because the effects of the SRB changes are overwhelmed by the present value of retired pay.

Random Shocks. We have seen that "ACOL focuses only on those who are on the margin of staying and leaving when only their tastes and financial incentives are considered." (1:27) It doesn't model how random shocks affect retention decisions. For example, someone with very strong tastes for service might leave because of a drastic negative shock, such as a family problem. In this sense, "everyone is on the margin of a stay/leave decision." (1:27) Arguden shows that this will cause the elasticity of retention rates with respect to ACOL to be underpredicted. Thus, we'd also underpredict the changes in retention resulting from any change in compensation policy that reduced ACOLs. (1:29)

THE DPAC IMPLEMENTATION OF THE ACOL MODEL

Finally, let's examine how the DPAC Compensation Model adapts the theoretical ACOL model for operational use. This can be seen most easily from the equation for $PVCOL_{t,n}$ (Equation 2-4), since $ACOL_{t,n}$ is just the annualized value of that measure. We'll first describe some refinements to the PVCOL equation; then we'll describe the data currently used for each of the compensation variables.

Refinements to the PVCOL Equation

Equation 2-4 requires that we know the values of expected military pay (M_t) and civilian pay (W_n and W_t) for the remainder of the member's working life, and the values of expected retirement earnings (R_n and R_t) until his death. In practice, all we usually know is the current year's (and possibly the next year's) military and average private-sector pay, and the rules for computing military retirement benefits based on the member's projected military pay in some future period(s). The permanent data base of the DPAC Compensation model has an officer and an enlisted data set for each fiscal year.¹⁵ Each of those annual data sets contains schedules of monthly military pay and allowances by rank and YOS (including Aviation Career Incentive Pay, or flight pay, for rated officers), and average pay for "comparable" civilians, as defined below.

Growth in Wages, Prices, and Retired Pay. When we execute the Model, it asks us for additional parameters that determine the system for computing military retired pay. We must also specify the personal discount rate d (which determines B in Equation 2-4), as well as the long-run rates of growth in prices and in military and civilian pay. The Model applies those growth rates to the starting (base-year) pay charts to compute the required nominal military and civilian pay for all future years.¹⁶ It then deflates that pay by a computed price index for each year to convert each future year's projected nominal earnings into base-year dollars, and finally discounts the earnings back to the base year. For each year in which the member is retirement eligible, annual retirement pay is computed based on the projected nominal pay for each of those years and the retirement system we select. The annual retirement pay figures are increased in subsequent

15. The documentation prepared by the Science Management Corporation shows the file layout for an example enlisted data set; officer data sets have a similar format. (25:A-1 - A-3)

16. Chapter Six provides further discussion of this process. As explained there, we can adjust the existing pay tables one time during each run to provide a different base to which the long-run growth factors would then be applied. The military pay table is broken down by rank and YOS, but the civilian pay tables are simple age-earnings profiles. Each YOS can be linked to a member's age, because the Model assumes officers enter the service at age 23 (so, for example, they are age 24 at the end of YOS 1) and enlisted members enter at age 19. Thus, we may think of Equation 2-4 in terms of either age or YOS.

years by the cost-of-living adjustment factor we specify. Each year's projected retirement pay is also deflated and discounted back to the base year. Note that the resulting PVCOL and ACOL values are therefore expressed in base-year dollars; e.g., if we begin with an FY 1987 pay table, our results are in 1987 dollars.

Other Adjustments.

Force Distribution. Each year's expected military pay term M_j is weighted by the probability of being in each possible rank in a given YOS. (Thus, each ACOL computation indirectly takes into account the historical mean promotion rate to each rank, including average chances for below-the-zone promotions as well as passovers.) Each fiscal year's permanent data set contains this percentage distribution, and we assume that it remains constant in all future years when computing ACOLs for any given case.

Probability of Living. Each fiscal year's data set also contains a mortality table, and the projected military, civilian, and retirement pay for each year are weighted by the probability of being alive in that year.

Measures of the Pay Variables

Military Pay. To measure M_j , we use the annual Regular Military Compensation (RMC). RMC is defined as a member's before-tax cash pay--Basic Pay, Basic Allowance for Subsistence (BAS), Basic Allowance for Quarters (BAQ), Variable Housing Allowance (VHA), and flight pay or bonuses (if applicable)--plus a "tax advantage" that is imputed to the member because the three allowances (BAS, BAQ, and VHA) are exempt from Social Security and Federal income taxes.¹⁷ (10:8) The "full" BAQ rate is used for members without dependents, and enlisted BAS is assumed to be the daily rate when rations in kind are not available, multiplied by 365 to get an annual rate. Because it includes the tax advantage of the allowances, RMC is usually considered the before-tax equivalent of a civilian salary.

Tax Advantage. The tax advantage imputed to each member is defined by law as the additional taxable income the member would have to receive, if his BAQ, VHA, and BAS were to become subject to Federal income taxes, in order to leave him the same after-tax income he received when those allowances were not taxed. (10:8 [fn. 5]) The DPAC Model also adds the tax advantage that accrues because the allowances are exempted from the Social

17. The definition of RMC was amended in 1980 to include VHA, but the Military Compensation Background Papers continued to use the previous terminology. (10:70 [fn. 9]) If VHA is excluded, the resulting compensation measure, including the imputed tax advantage, is called Basic Military Compensation (BMC). Analysts in the Compensation Directorate of the Office of the Assistant Secretary of Defense for Force Management and Personnel (OASD/FM&P) often use BMC instead of RMC, since VHA varies by geographic area. OASD/FM&P also excludes the imputed Social Security tax advantage from its published tables.

Security tax as well.¹⁸ Each year's permanent data set contains Federal income tax tables, Social Security tax data for that year, and a distribution of the family sizes of AF members by grade.^{19,20} The imputed tax advantage is a weighted average across family sizes.

Civilian Pay. The data bases currently contain average annual incomes from wages and salaries for civilians, by age, obtained from Census or Current Population Survey (CPS) data. For officers, regardless of rated status, the earnings of male college graduates are used; for enlisted personnel, the earnings of male high school graduates. In previous years when Census or CPS data weren't obtained, the data series were updated by the percentage increase in the PATC index, which has been superseded by the ECI (see Chapter Four). The Model assumes that once a member leaves the service

18. A change in tax rates causes the imputed tax advantage to change too, of course. But the tax advantage has a peculiar property: Holding income constant, an increase in tax rates causes an increase in the tax advantage, thus an increase in RMC, despite the net decrease in the member's after-tax income as a result of the tax increase. "Conversely, a decrease in tax rates causes a decrease in the tax advantage, and hence RMC--although a member's after-tax income will increase." (10:71 [fn. 10])

19. As of this writing, several of the officer and enlisted data sets contain an error in their tax data: In the line of data separating the tax tables from the family-size distribution, the sixth (last) data element is a reduction factor that allows the user to decrease or increase income taxes by an across-the-board percentage. Normally this datum should be "0," but in some data sets "0.10" appears, causing an unintended 10 percent tax cut from the rates in the tax table. Theoretically, even if such a tax cut were consistently applied to all years' ACOLs (including those in the DOPMS and EPOM base-year ACOL files), we might still find that the resulting ACOL changes between two compensation alternatives would cause different changes in retention rates. This is because both the logistic functional form (which the retention regressions and elasticities are based on) and the tax tables are nonlinear. Experimental DOPMS runs have shown almost no differences in forecasted officer losses because of this error, at least in the current range of retention rates and tax rates. However, enlisted retention rates are more sensitive to ACOL changes than officer rates are, so the differences in forecasted enlisted losses as a result of this error may be more significant. In addition, there's something to be said for correcting the data bases for this systematic error to avoid inadvertent comparisons in the future between sets of ACOLs that include the tax cut and sets that don't.

20. The documentation by Science Management Corporation for these data sets contains an error on this point. The distribution is by family size, not by number of dependents. (25:A-3) The tax tables are obtained from OASD/FM&P, but they are essentially Schedules X and Y (for single and married members, respectively), plus other basic tax data like the personal exemption.

(whether or not he stays in until retirement eligibility), he has post-service civilian employment and earnings through age 64, weighted by the probability of being alive in each year. (12:1-1) For those leaving the service with 16 or more YOS, the Model reduces the civilian pay stream by 5-15 percent, based on the rank and YOS at separation, to account for the probability that these persons will be paid less than statistically similar civilians. (12:5-7)

Expected Value of PVCOL and ACOL

As just described, the income components of PVCOL and ACOL are weighted by the distribution of the force by grade for a given YOS, the probability of living until the year the income is received, and the distribution of family sizes among members. Therefore, the Compensation Model's PVCOLs and ACOLs represent expected values, or values for an average member.

The Logistic Distribution

The logistic distribution isn't a property of the ACOL model per se, but it is the basis for applying ACOLs to retention modeling. When estimating a regression equation for retention rates as a function of ACOL and other variables, tastes for service are usually assumed to have this distribution. (1:25; 4:5,9) That is, if r_t is the retention rate for the cohort completing YOS t and $ACOL^*_t$ is their maximum ACOL value, then we assume that, all other factors held constant,

$$r_t = \frac{1}{1 + e^{-(a_0 + a_1 ACOL^*_t)}}, \quad (3-12A)$$

where a_0 and a_1 are parameters to be estimated by the regression. (Other independent variables are just appended to the exponent of e .) This arcane-appearing functional form is used because it has three intuitively appealing properties. First, its elongated-S shape is asymptotic to 0 and 1; i.e., retention rates are bounded by 0 and 100 percent. Therefore, the model could never forecast a rate outside those bounds, as some other functional forms, like a linear one, could. Second, it exhibits diminishing marginal returns on both extremes: the elasticity (responsiveness) to pay changes decreases as the retention rate approaches 0 from the right and 1 from the left, which seems realistic. (1:20 [fn. 13]) And third, the functional form is log-linear; i.e., Equation 3-12A can be rewritten as

$$\ln \frac{r_t}{1 - r_t} = a_0 + a_1 ACOL^*_t \quad (3-12B)$$

This functional form is relatively easy to handle, both mathematically and econometrically.

Chapter Four

EMPIRICAL ECONOMIC ASSUMPTIONS I: WAGE AND PRICE GROWTH RATES

As the formula for ACOL shows, we must specify a number of parameters when running the Compensation Model. The validity of the resulting ACOLs, and of any subsequent forecasts of retention and force-structure changes, depends crucially on the plausibility of these assumptions. Four of these parameters in particular require us to apply our economic judgment; those are the long-run values of the real discount rate and the annual rates of growth in consumer prices, military pay, and private-sector (i.e., civilian) pay.¹ There is no clear-cut answer to the question of what values we should assume for these parameters, but there are several economic principles that should serve as guidelines or "reasonableness tests." It cannot be over-emphasized that we must be aware of the broader economic consequences implied by our assumptions.² This chapter and the next one discuss the considerations that should guide them.

THE PRINCIPLES OF REAL WAGE GROWTH AND RELATIVE WAGES

In most compensation-analysis scenarios, we assume that (positive) long-term growth in prices, nominal military pay, and nominal private-sector pay will occur. In such cases the Compensation Model asks us to "enter CPI, mil wage growth, civ wage growth %s."³ It is a fortunate coincidence that the Model requests these three values in the same question, because this allows

1. As Chapter Six explains, the Compensation Model asks for the nominal discount rate when a run specifies long-run growth in prices. The nominal rate depends on the assumed inflation and real discount rates, which are the more fundamental economic variables. Once they are specified, the nominal discount rate is also determined, as shown in Chapter Five.

2. And these assumptions should always be documented to provide an audit trail.

3. The question is actually asking for the Consumer Price Index (CPI) growth rate (the "inflation rate"), not the value of the index itself. The rates of growth in prices and nominal wages (i.e., wage growth before correcting for inflation) together determine the change in real wages (wage growth adjusted for inflation), as shown below. In this chapter, the terms "wages" and "pay" are used interchangeably.

us a convenient chance to check the economic reasonableness of our assumptions about these parameters.

Two Basic Criteria

The two economic principles that should govern our wage-behavior assumptions for most Compensation Model runs are particularly important to consider because they often contradict both the conventional wisdom and, in some cases, recent historical experience. The latter two influences are strong ones and may lead an unwary analyst to make assumptions that are seen to be unreasonable when examined in the light of the following criteria:

Real Wage Growth. The long-run rate of real wage growth should not be negative.

Relative Wages. The long-run rates of military and civilian wage growth should be equal, so that the relative wage remains constant.

These principles merit further discussion to resolve their apparent conflict with what may be commonly believed about relative wages and growth in real wages.

Real Wage Growth

To assume that real wages will increase (or at least not decrease) in the long run may seem to require a leap of faith in view of the behavior of some real-wage measures over the last 10 to 15 years. But the validity of this tenet can be seen by understanding the basic economic forces that determine the behavior of real wages over time. Changes in average real wages in an economy are determined by a combination of two factors: changes in national output per man-hour of labor employed (i.e., "labor productivity") and changes in the percentage of national income that is earned by labor ("labor's share of income"). At least since the turn of the century, growth in labor productivity has been the dominant factor in accounting for the average increase in real wages in the US economy. (3:228,243-245)

Rate of Growth in Real Wages. Let us begin our analysis of the behavior of real wages by defining the following variables:

W = an index of average nominal wages;

w = the annual rate of change in nominal wages, expressed as a decimal fraction (i.e., if the rate of change is 5 percent, then $w = 0.05$);

P = an index of average prices;

p = the annual rate of change in prices (the inflation rate), expressed as a decimal fraction;

q = the average rate of change in labor productivity (i.e., of output per man-hour), expressed as a decimal fraction.

Assuming that labor's share of national income is constant, it can be shown that the following identity holds:⁴

$$p = w - q . \quad (4-1A)$$

That is, the average inflation rate in the economy equals the average rate of change in nominal wages minus the average rate of change in labor productivity. Rearranging terms, we have:

$$q = w - p . \quad (4-1B)$$

The Role of Productivity Growth. The average real wage is just W/P , so Equation 4-1B allows us to determine the direction of change in the real wage once we know the algebraic sign of q , the rate of change in labor productivity. There are three possible cases:

1. If $q < 0$, then $p > w$, so real wages will fall.
2. If $q = 0$, then $p = w$, so real wages won't change.
3. If $q > 0$, then $p < w$, so real wages will rise.

Therefore, to determine whether real wages will rise, remain constant, or fall, we need to know only the direction of change in the productivity of labor!

The relationship of the rate of change in real wages to w and p can be derived as follows: Since P and W are the indexes of average prices and nominal wages in any given year and W/P is the average real wage, the following year these variables will have the values $P(1+p)$, $W(1+w)$, and $[W(1+w)] / [P(1+p)]$. Therefore, the rate of change in average real wages w' is by definition

$$w' = \frac{\frac{W(1+w)}{P(1+p)} - \frac{W}{P}}{\frac{W}{P}} ,$$

4. "Labor's share" is defined as total income earned by labor as a percentage of the total income earned by all factors of production. Note that Equations 4-1A and 4-1B are identities, not equilibrium conditions; that is, under the conditions assumed, these equations are always true theoretically. Intuitively, $w - q$ is just the rate of change in unit labor costs, and unit labor costs are the income earned by labor. If factor shares are to remain constant, then the incomes earned by the nonlabor factors must also increase by this proportion on average. This requires that average prices rise at the rate $p = w - q$.

which simplifies to

$$w' = \frac{(1 + w)}{(1 + p)} - 1 \quad (4-2A)$$

$$= (w - p) / (1 + p) \quad (4-2B)$$

$$= q / (1 + p) . \quad (4-2C)$$

(Multiplying the resulting rate of change by 100 percent expresses it as a percentage.) Thus, if we know the values of any two of the three variables in Equation 4-1A, we can compute the corresponding rate of change in the average real wage.

Equation 4-2C is the key to the assumption that real wages will increase in the long run because it shows that real wages will grow (w' will be positive) as long as labor's productivity grows (i.e., when q is positive), regardless of the inflation rate. As we'll see, a secular upward trend in labor productivity has characterized the US economy since World War II. This trend has been the primary cause of the long-run increase in real wages over the same period, as mentioned previously.

Two Rules of Thumb. The rate of change in the real wage is often defined as just $w' = w - p$, but as Equation 4-2B shows, this isn't exactly correct. However, $w - p$ is a convenient approximation that is accurate enough to be useful in many situations. The lower the inflation rate, the closer the approximation will be, but the actual growth rate will always be overstated by a factor of $(1+p)$, or $(p \times 100)$ percent, when the inflation rate is positive. Particular caution is necessary when using such approximated rates compounded over even a few years, since the original error also compounds.

Equation 4-2C provides the basis for another useful rule of thumb: Assuming that labor's share of national income remains constant, the average real wage will grow at approximately the same rate as the rate of growth in the average productivity of labor. (The lower the inflation rate, the better the approximation will be.)

Labor's Share of Income. Before turning to the secular trend in productivity and real wage growth, let's briefly examine the assumption that Equations 4-1A, 4-1B, and 4-2C are based on, namely, that labor's share of national income remains constant. A detailed treatment of labor's share of national income, or output, is beyond the scope of the handbook.⁵ However, the relevant conclusions can be summarized here and are useful in appreciating the broad applicability of Equation 4-1A and its economic implications for ACOL assumptions.

5. Reynolds gives an excellent overview of the theory and empirical evidence on labor's share of income. (3:228-249) Discussion of this esoteric subject should be confined to consenting, adult labor economists and should never be permitted in polite company.

Short-Run Changes in Labor's Share. There is wide agreement among researchers that labor's share of income tends to vary countercyclically: historically it has declined during economic expansions and risen during economic contractions.⁶ (3:242-243)

Long-Run Changes in Labor's Share. Although the empirical evidence on long-run trends is mixed, Reynolds concludes, based on his survey of the available studies, that labor's share has increased moderately since the turn of the century, from around 70 percent to around 80 percent.⁷ (3:243-245) His assessment is that this "modest increase in labor's share . . . is much too small to explain the rapid rise in real wage rates." (3:246) From the studies he surveyed, he estimates that the secular increase in labor's share could account for only about a quarter of a percentage point per year in the growth of real wages from 1900 to 1970, while their actual growth rate over that period was about 3 percent per year. (3:246) (We may surmise from his analysis that cyclical changes in labor's share would have an even smaller impact on short-run growth in real wages.) He concludes:

The main reason for rising real wages, obviously, is that the pie itself has been growing. There has been a rapid rise in total output and in output per man-hour of labor employed. Labor earns more year by year mainly because, as a result of technical progress and additions to physical and human capital, labor is becoming steadily more productive. (3:246)

Real Wage Growth: The Data. Finally, let's look briefly at the data on the actual growth in real wages that Reynolds is referring to.

A Qualification. Empirically, the relationships in Equations 4-1A, 4-1B, and 4-2C between growth in productivity and in real wages may not hold in the short run because of lags in the adjustment of wages and prices to productivity changes. In addition, published data for wage, price, and productivity growth don't hold labor's share constant. However, the data conform more closely to the theory over longer periods of time, e.g., over a complete business cycle, even before adjusting for changes in labor's

6. This observed behavior is usually attributed to the "capacity effect": Assume that during a recession most firms operate below capacity, i.e., to the left of the minimum points on their U-shaped average total cost curves. As output rises during an expansion, average fixed costs and average variable costs tend to decline. Thus, short-run profits occur because changes in prices and wages tend to lag behind the changes in production costs. This causes profit's share of income to increase and labor's to decrease during the expansion. The opposite happens when a recession begins. (3:242)

7. Long-run changes in labor's share depend on two characteristics of an economy's technology of production: the elasticity of substitution among factors of production and the labor- or capital-saving bias of technological change. See Reynolds' overview of the theory of these concepts and their effects on factor shares. (3:237-241)

share.⁸ In simulation terminology, we may think of these equations as "steady-state" relationships.

Long-Run Productivity Growth. From 1947 through 1985, labor productivity in the nonfarm business sector of the US economy increased in all but seven years. Its average growth rate over this period was 2.3 percent per year. Although the growth rate in productivity declined markedly in the mid-1970s compared to its performance over the previous 30 years, it still averaged 1.0 percent per year from 1975 through 1985.⁹ (9:302 [Table B-43]) This long-term growth in labor productivity has provided the basis for the corresponding growth that has occurred in real wages since World War II, as Equation 4-2C would predict.

Long-Run Growth in Real Wages. From 1947 through 1985, real, adjusted average hourly earnings (AHE) grew at an average compounded rate of 1.3 percent per year. However, the average growth rate has shown a downward trend since 1947, and real wages actually declined in 8 of the 13 years from 1973 through 1985. Over that period, real, adjusted AHE fell at a compounded annual rate of 0.54 percent.¹⁰ (9:302 [Table B-43]) Real wages

8. These three variables follow relatively predictable patterns over the business cycle. During a recession, the lower growth rates in real economic activity tend to be associated with lower rates of growth in nominal wages and prices, other things remaining the same, while higher real economic growth is associated with faster nominal wage and price growth after a recovery gets underway. Labor productivity and its growth rate also vary systematically over the cycle. At the onset of a recession, employers tend to reduce output faster than they reduce employment ("labor hoarding")--essentially, they slow down their production lines. Thus, output per man-hour falls (the rate of growth is negative). At the beginning of the subsequent economic expansion, employers tend to increase output faster than they increase the number of workers employed or hours worked, so productivity grows at a faster-than-average rate. Such short-term swings must not be interpreted as changes in the long-term trend.

9. This slowdown has been attributed to various combinations of a number of factors. Two of the most widely agreed-on causes are the secular rise in the labor-force participation of women (whose productivity is lower than average, due in part to their below-average experience) and the long-term increase in the proportion of total employment occurring in the service sector of the economy (where average productivity grows at a significantly slower rate than in the goods-producing sector). Note that the effect of these factors has only been to reduce the long-run average rate of growth of productivity, not to reduce the absolute productivity rate itself (average output per man-hour employed), which has continued to grow over the long run.

10. During the 1981 - 1982 recession and the initial years of the subsequent recovery, temporary wage and benefit "givebacks" by major labor unions in troubled industries were highly publicized. (8:32-33) However, these contract concessions directly affected only a minority of the labor

turned upward again over the 1982 - 1985 period, as we would have expected to occur eventually because of the continuing increase in labor productivity, barring a radical and unprecedented decrease in labor's share of income. (9:300 [Table B-41])

Long-Run Real Wage Growth and the Standard of Living. One of the economic effects of real wage growth is to raise the average standard of living.¹¹ Negative growth in real wages over a long period almost certainly means declining living standards on the average, and few analysts expect that to occur in the US economy over anything but the short-run. This is the ultimate intuitive justification for assuming a non-negative growth rate for average real wages for ACOL runs. That is the first and greatest commandment, and the second is like unto it.

Relative Wages

Once an assumption has been made for the long-run growth rate for civilian wages, the assumed long-run military-pay growth rate should be equal to it in general, so that the relative wage remains constant. This principle appears to contradict the conventional wisdom, especially among many policy makers, that Federal budget constraints will keep military-pay raises lagging behind those in the private sector for the foreseeable future. It also conflicts with our historical experience over some periods during the All-Volunteer Force (AVF) era, as we'll see.

Relative Wages and the Law of Supply. However, before examining the historical relationship between military and civilian wage growth, consider the long-run economic implications of unequal wage growth between these two sectors of the labor market. The well-known Law of Supply predicts that if wages fall in one occupation relative to those in another, the quantity of labor supplied to the occupation with falling relative wages will decrease, while the quantity supplied to the other occupation will increase, other things being equal. Thus, if civilian pay grows faster than military pay, we'd expect the decline in relative military pay to cause an eventual decrease in retention. Presumably, this decline in retention would eventually impair national defense enough to induce the Administration and the Congress to reverse the downward trend. The fall in retention the Air Force experienced in the late 1970s and the subsequent increase in the early 1980s are consistent with this economic law: Relative military pay declined from Fiscal Year (FY) 1974 through FY 1980, and retention measures reached their

force, and many of those agreements have since expired. Those concessions made after the expiration of multi-year contracts lagged behind the recession's downward pressure on wages, and those givebacks contained in new multi-year contracts without renegotiation or restoral provisions will cause covered wages to lag behind the subsequent increases that have occurred in average wages.

11. This assumes real wages grow faster than the population, that is, real per capita incomes increase, which is typically the case in developed countries. Hours of work should also be held constant.

lowest levels in AVF history in the late 1970s. Relative pay then rose in FYs 1981 and 1982, and retention also turned upward. (13:--) (The behavior of the civilian unemployment rate during this period was also a powerful economic influence on retention; DPAC's econometric studies show the statistical significance of both the unemployment rate and relative compensation, as measured by ACOLs, in explaining retention behavior.)

It is important to recognize that this principle applies to long-term relative wage growth. There may be valid, compelling reasons to expect military pay to grow faster or slower than civilian pay in the short run (e.g., because of the requirements of the Balanced Budget and Emergency Deficit Control Act of 1985, known as the Gramm-Rudman-Hollings Act). In such cases, the resulting decreases in retention and their force-structure impacts provide data for Air Force policy makers to use in arguing against such relative wage cuts and in planning how to cope with their effects if they occur. But this is a greatly different matter from assuming that relative military pay will decline ad infinitum. However, we should also recognize that assuming constant relative wages extends any existing military-civilian pay-comparability gap into the future.¹²

In addition, none of this is to imply that the Law of Supply as it applies to the market for military labor is understood, or at least considered to be of continuing importance, in the smoke-filled cloakrooms on Capitol Hill. Quite to the contrary, historical experience suggests that both the Congress and the Administration are willing to allow relative military pay to fall until its effects become too serious to ignore any longer, as we'll see next.

Relative Wages: The Historical Record. Examining the history of relative military pay during the AVF shows the pitfalls in attempting to choose a nonzero differential between the growth rates for military and civilian pay over the long run. Table 2 summarizes how the growth of real wages has varied during the AVF period. These data show the average compounded rates of change in military pay and three measures of civilian pay, corrected for inflation, from FY 1972 (the first full year of the AVF) through FY 1985 (the last year for which complete data were available). The table also shows the rates of change for two periods during the AVF: FY 1972 - FY 1979 and FY 1979 - FY 1985. (In 1979 the gap between military and civilian pay was the widest in the AVF's history up to that time; in that year Congress and the Administration began measures that eventually restored comparability temporarily.)

12. See the section on "Alternative Scenarios" below for a related discussion. As of this writing, the DPAC Compensation Model only allows the user to specify one pay growth rate for the future. That rate applies to all years after the current one. Major Vetterlein is modifying the model to allow for different growth rates during the Five-Year Defense Program period.

Compounded Annual Rates of Change
in Indexes of Real Earnings

Period (FY)	Military*	PATC*	ECI**	AHE***
72 - 85	-0.88%	-0.11%	-	-0.54%
72 - 79	-2.13	-1.19	-	-0.54
79 - 85	0.61	1.17	0.67	-0.54

* Military pay and PATC indexes constructed from (13:--); deflated by CPI-U from (9:315 [Table B-55]).

** Publication of ECI began in 1977.

*** Constructed from (9:300 [Table B-41]).

**Table 2. Changes in Measures of Real Earnings
Under the All-Volunteer Force¹³**

The index of the earnings of professional, administrative, technical, and clerical workers (PATC), which has been discontinued, was based on data from an annual survey of wages conducted by the Bureau of Labor Statistics (BLS) and weighted by the President's Pay Agent (a Cabinet subcommittee) to reflect the occupational distribution of Federal employment. Until 1985 the PATC index was the official basis for determining the comparability of military and Federal Civil Service (General Schedule) pay with private-sector pay. In 1985 the Pay Agent began using the March value of the Employment Cost Index (ECI), a quarterly BLS index of average hourly compensation for all nonfarm workers in the private sector and in state and local governments (Federal employees are excluded).¹⁴ (7:78,80)

13. To compute the real rates of change in Table 2, fiscal-year indexes for military pay, PATC, and ECI were constructed from data on their nominal annual rates of change using the data in (13:--). These nominal indexes were then deflated by the annual average Consumer Price Index for All Urban Consumers (CPI-U) for the corresponding calendar year. (E.g., FY 1985 used the CPI-U value for CY 1985.) Fiscal-year CPI-U averages could be constructed and used if desired.

14. Since the ECI includes employees of state and local governments, it's not technically correct to refer to it as a measure of private-sector

The adjusted average hourly earnings (AHE) index data are for private, nonfarm, production or nonsupervisory workers, adjusted for overtime and interindustry shifts in the composition of employment, and corrected for inflation.¹⁵ (9:300 [Table B-41]) The AHE index has the advantage that it is regularly forecasted by at least one of the econometric forecasting services (without correction for inflation), while the ECI isn't yet forecasted by any of them.

As the data in Table 2 show, how relative military pay has fared over the AVF depends on what period we look at and which measure of civilian wages we use as a benchmark. Military pay has never kept pace with the PATC index (which may have contributed to the latter's political demise as a comparability standard), while the ECI has increased by an average of less than one-tenth of a percentage point per year faster than military pay since 1979.¹⁶ The AHE measure declined at an average annual rate of 0.54 percent over both the subperiods shown in Table 2; since 1979 military pay has grown faster than AHE by an average of almost 1.2 percentage points per year. Because these comparisons are very sensitive to the choice of beginning and ending years, historical experience provides at best vague, and at worst misleading, guidance in attempting to determine what the differential in growth rates between civilian and military pay "should" be. Therefore, to assume that military pay will grow at a slower rate than civilian pay over the long run is necessarily a somewhat arbitrary decision that ignores the labor-supply principle discussed above.

Ignoring that principle has significant empirical consequences because ACOL computations involve such long time horizons. A member in YOS 1 must take into account up to 29 additional years of military pay; thus, even relatively small differentials in pay growth rates compound into substantial differentials in relative military-civilian pay. For example, if military pay raises were to be only 1 percentage point less than civilian raises, the

pay, but we'll continue to do so for convenience in terminology. In addition, following the procedure used by the President's Pay Agent for determining the size of recommended increases in General Schedule pay (therefore in military pay under Title 37, Section 1009, of the US Code), the ECI used in Table 2 for a given fiscal year is taken as the value for the March preceding the beginning of that fiscal year. E.g., the ECI value used for FY 1985 (which began 1 October 1984) was that published by BLS in March 1984, deflated as explained in the next footnote. BLS also publishes ECI series that include "fringe benefits."

15. The AHE index for each fiscal year was taken as the value for the calendar year number corresponding to the fiscal year, deflated as explained in the previous footnote. E.g., the AHE index used for FY 1985 (beginning 1 October 1984) was the value for calendar year 1985. Again, fiscal-year averages could be constructed and used if desired.

16. In FY 1979 military pay was below the comparability level. In FY 1981 comparability had been essentially restored, but the pay gap has widened every year since then. (13:--)

ratio of military pay to civilian pay 20 years later would be 81 percent (0.99²⁰) of its original value. Depending on the elasticity of supply of labor, this could result in significant increases in losses in some YOS groups compared to the case in which military and civilian pay grow at the same rate. As discussed below, it would be appropriate to make such an assumption about differential pay growth rates for some alternative scenarios (e.g., a "worst case"). But in most situations, especially a base case, we should assume that military and civilian pay grow at the same rate.

MAKING LONG-RUN WAGE ASSUMPTIONS IN PRACTICE

Once the principles in the preceding section are understood, deciding on long-run civilian wage and price growth rates is fairly straightforward in most cases. As mentioned previously, such econometric-forecasting firms as Data Resources, Incorporated (DRI), Wharton Econometrics, and Chase Econometrics regularly publish relatively objective, statistical estimates of expected growth in prices and civilian wages. These published forecasts have several advantages.¹⁷ Besides being fairly readily available and frequently updated, their credibility and political neutrality are widely recognized (in contrast to those of the Office of Management and Budget, for example, which DPAC must sometimes use for budget exercises). In addition, because these firms' econometric models are based on historical data and account for the interrelationships among economic sectors, the real-wage growth principle is implicit in their forecasts. Finally, each service provides both short-term and long-term forecasts for at least three scenarios: an economically optimistic case, a pessimistic one, and a control (or most likely) case. Thus, some average measure, or consensus, of their control forecasts gives us the civilian wage and price growth parameters we need in a wide variety of scenarios, such as base cases.¹⁸

17. The qualifier "relatively" is necessary because all these models' macroeconomic forecasts ultimately require assumptions about such discretionary economic influences as monetary and fiscal policy. The three services mentioned here are the ones to which DPAC held subscriptions as of this writing. Of these three, only DRI forecasts the nominal adjusted-AHE measure, but all three forecast other wage series.

18. Determining an appropriate consensus measure is a matter of judgment. For example, each of the econometric services publishes a control forecast of CPI-U growth. We could use the median of their respective control forecasts as a consensus for our most likely case, since the median eliminates the influence of extreme values. However, in DPAC we've usually used the arithmetic mean of the forecasts because it gives equal weight to each of the estimates; we typically want to include, not exclude, the information represented by any outliers.

Base Case Parameters

Types of Base Cases. The type of base case we have will affect our assumptions. A base case is just a benchmark forecast, along with its associated assumptions, to which alternative forecasts will be compared. In practice we may distinguish three types of base cases: first, the expected, or most likely, case; second, a continuation of the status quo; and third, some other set of assumptions that the policy maker or analyst wishes to use as a benchmark. (The three categories aren't necessarily mutually exclusive; e.g., the most likely case may involve continuing the status quo, at least in part.) In much of DPAC's work, the presumption often exists that a base-case forecast is of the first type unless otherwise specified.

Growth in Prices and Civilian Wages. Here are some factors to consider in selecting base-case assumptions.

Expected Case. Some consensus based on the control scenarios of the commercial econometric forecasts is tailor-made for this purpose. Usually, no modifications are necessary, except possibly for rounding to the nearest percentage point or one-half of a percentage point for convenience in presentation.¹⁹ In this author's experience working with these forecasts from 1983 through mid-1986, the forecasted long-run growth rate for nominal wages tended to exceed that for prices by roughly one percentage point, yielding real wage growth of about one percent.

Status Quo. In this case, we answer such questions as, "What will happen to retention if real wages continue to grow in the future at the same rate they've been growing recently?" The danger exists here of perpetuating short-term relationships that ignore the principles discussed above, and the reasonableness of the resulting analysis suffers accordingly. Great caution is necessary when using recent experience as a guide, particularly when it reflects an extreme situation or a trend reversal compared to the historical record. (Indeed, how would we define "recently"?) For example, examining the commercial economic forecasts published over the last few years shows that all expect a gradual increase in the real-wage growth rate over the next few years, not a continuation of the recent stagnation in real wages. Although the status quo is often a valid scenario to examine, its validity is sometimes as a best or worst case, not as a base case.²⁰

Other Base Cases. The two economic principles discussed in this chapter constrain the choice of assumptions in such cases only to the extent that we want our conclusions to be economically reasonable. As always,

19. Whether the inflation rate is 4.3 or 4.5 percent has only a negligible impact on ACOLs and retention forecasts, and the rounder number is more likely to stick with the audience if they care to remember it.

20. In the context of the ACOL Model, this discussion of the status quo as a base case applies only to our macroeconomic assumptions. In other instances, the status quo is usually in fact the base case, e.g., in specifying what retirement system to use in computing ACOLs.

however, the economic implications of any assumptions should be recognized, reasonable or not.

Relative Military Pay. This is a key policy variable controlled jointly by the Congress and the Administration. As a policy variable, it isn't amenable to econometric forecasting in the same sense as macroeconomic variables are. Who can claim any credibility in forecasting the long-run course of relative military pay--indeed, even the next fiscal year's raise a year in advance--except possibly for certain broad upper and lower limits?

Expected Case and Status Quo. Because of these uncertainties, this author tends to rely even more strongly on the principle of maintaining constant relative wages, which requires that military and civilian wages grow at the same rate. That is, the status quo is assumed to be the most likely case.

Other Base Cases. On the other hand, especially in the Gramm-Rudman-Hollings environment, some analysts can advance reasonable arguments that pay comparability will continue to decline, although this assumption begs the questions of "by how much?" and "for how long?" Again, as Table 2 reminds us, the AVF experience provides a diverse menu of possible answers. Whatever the assumption we finally make, we need to be aware of its underlying economic implications.

Parameters for Alternative Cases

For convenience, we may distinguish between two types of alternative cases, i.e., those to be compared with the base case: first, best- and worst-case scenarios; and second, some other set of assumptions that the policy maker or analyst wants to consider, including a subset of extreme cases.

Best and Worst Cases. These scenarios, which sometimes may more accurately be called high-low or optimistic-pessimistic comparisons, are usually feasible ones with some reasonable possibility of occurring, although they may be considered less likely than the base case.²¹ Since the econometric forecasting firms provide such forecasts for growth in prices and civilian wages, along with the subjective probabilities they assign to these alternatives, these provide reasonably objective alternative cases.

21. Caveat: When using these comparative terms, we must specify whether the best and worst cases are from the perspective of the economy's performance or from that of Air Force retention. E.g., an economic best case means higher economic growth, which usually reduces the unemployment rate (and may also raise inflation). But a lower unemployment rate, other things being equal, will tend to reduce retention--a worst case from the Air Force's point of view. On the other hand, if greater economic growth generates higher tax revenues, a higher military pay raise may be more feasible than if growth and tax revenues were lower. It all depends on the elasticities.

Real Wage Growth. In this author's experience, most of the forecasters' alternative cases concentrate on monetary and fiscal policy assumptions, or on special topics like major shifts in oil prices. Thus, they don't usually change such underlying economic relationships as that between growth in productivity and real wages. As a result, higher rates of economic growth will entail greater real wage growth to the extent that the economic growth is accompanied by higher growth in productivity. The forecasted nominal series must be compared to see what growth rate in real wages is expected.

Relative Military Pay. Keeping the relative wage constant in these alternative cases would leave real wage changes as the only source of changes in ACOLs, while allowing the relative wage to rise or fall could be used to reinforce or partly offset the impact of the change in real wages. There are no convincing logical or theoretical reasons for favoring either of these alternatives over the other, as a general rule.

Other Alternatives. Besides the feasible best and worst cases, there are any number of other alternatives, some feasible, others very unlikely. For example, we may want to examine a scenario that falls between the base and worst cases. On the other hand, we may want to run extreme cases at either end of the spectrum, e.g., to answer such questions as, "What if the relative wage were to decline indefinitely at its average rate of decrease since FY 1982?" Although such degenerative cases are unlikely to occur in reality, they sometimes provide useful comparisons.

Real Wage Growth. The guiding principle remains the same: it probably isn't economically meaningful to assume a significant long-term decline in real wages.

Relative Wages. As in the best and worst cases above, economic theory provides no constraints or guidance here, except to be aware of the economic implications of our assumptions.

CHAPTER FIVE

EMPIRICAL ECONOMIC ASSUMPTIONS II: THE REAL PERSONAL DISCOUNT RATE

Of all the parameters the user must specify in running the Compensation Model, few are potentially as controversial as the real personal discount rate, and none is more so. Because of its implications for military personnel costs, the compensation-policy impact of the discount rate assumption can take on political dimensions that belie the concept's arcane nature. Ironically, we have relatively little empirical knowledge about this key policy parameter. This chapter explains the policy importance of the discount rate and summarizes the theory and data on what should be assumed for its value in practice.

THE IMPORTANCE OF THE DISCOUNT RATE ASSUMPTION

Policy Implications

The real personal discount rate reflects an individual's preference for current instead of future income--income now rather than later.¹ Its policy importance stems from its role as a dominant determinant of the present value of a service member's lifestream retired pay (or of any other form of deferred income). At relatively low discount rates, retired pay constitutes a substantial fraction of the present value of a member's total lifestream earnings. This means that, other things being equal, a given change in expected military retirement benefits would cause relatively smaller changes in ACOLs (hence, relatively smaller changes in retention) at higher real discount rates than at lower ones. That is, the higher the discount rate, the lower the retention incentive provided by the military retirement system at any YOS. Thus, if we believed the real discount rate to be relatively high, we would forecast that substantial cuts in retirement benefits would cause relatively few additional personnel losses, while generating as much as several billion dollars of savings in the retired-pay subaccount of the Military Personnel Appropriation of the Federal budget. In a budget-cutting environment, then, the value of the real personal discount rate becomes a key assumption in analyzing compensation policy options.

1. The real personal discount rate is also known as the rate of personal time preference, the subjective discount rate, and various combinations of these terms.

Completed YOS	No. of Years Discounted (20 - YOS)	Discount Rate					
		1.0%	3.0%	5.0%	10.0%	15.0%	20.0%
0	20	\$820	\$554	\$377	\$149	\$ 61	\$ 26
4	16	853	623	458	218	107	54
8	12	887	701	557	319	187	112
12	8	924	789	677	467	327	233
16	4	961	889	823	683	572	482

Note: Values are rounded to nearest dollar. (2:137-142 (Table A-1))

Table 3. Present Value of \$1000 Payable After 20 Years of Service

The Discount Rate and Present Values

As the formulas for PVCOL and ACOL show, these models use the discount rate to combine streams of future income payments into a single present-value measure, or an annualized equivalent, that can be compared to current pay. (6:1,8) To illustrate the impact of the assumed discount rate on the present value of future income, Table 3 shows the discounted value of \$1000 payable after 20 years of completed service as it would be evaluated by service members at certain completed-YOS points and at various discount rates. (The \$1000 can be interpreted either as part of the member's annual retirement pay or as part of the present value of his stream of lifetime military retirement income, discounted to the 20 YOS point.) For example, consider a member completing 4 YOS: Each \$1000 of income expected at the end of 20 YOS would be worth \$853 to him at a 1.0 percent discount rate, but only \$54 at 20.0 percent--about one-sixteenth as much! As Black observes:

The repercussions for retention analyses of current and proposed retirement systems (as well as other forms of delayed compensation) are quite clear. A lower discount rate will (1) extend the range of the "pull" effect of future benefits, as well as (2) strengthen the impact of the "pull" effect by increasing the present value term. (6:2)

THE THEORY OF THE PERSONAL DISCOUNT RATE

In Chapter Four we saw that economic theory and readily available data provide us relatively useful guidance for formulating our assumptions about real wage growth and relative wages. In contrast, institutional constraints in capital markets limit our ability to deduce personal discount rates from observable market interest rates. To understand why this is so, we must

first understand the basic theory of personal discount rates, the imperfections in real-world capital markets, and the interaction between the two.

The Personal Discount Rate in a Perfect Capital Market

Assume for the moment that the inflation rate is zero. According to the neoclassical economic theory of consumer behavior, an economically rational person, given the choice between \$1.00 now and \$1.00 later, would always prefer the income now, even if there were no risk of loss involved in delaying the income until later.^{2,3} This preference arises because of the two possible uses to which he can put current income: first, immediate consumption, which increases his satisfaction or utility; and second, saving or investment, which would earn a return, making the \$1.00 worth \$1.00(1+u) in the next period, where u is some real market interest rate.

The real personal discount rate r is defined as the rate of return that makes an individual indifferent between an additional \$1.00 of purchasing power now and a riskless \$1.00(1+r) in additional purchasing power one period from now.⁴ Black shows that this condition can be expressed as:

2. In his study for the Fifth Quadrennial Review of Military Compensation, Matthew Black gives an excellent introduction to the theory of personal discount rates. (6:58-59) The discussion in this section has benefited greatly from Black's paper. Caveat: Black's Table 1 (page 2) and all his calculations following page 8 assume continuous compounding because it has certain convenient mathematical properties. That method yields slightly smaller present values than periodic (once per period) compounding. (6:8) However, his discussion of present value and the personal discount rate on pages 6-7 is in terms of periodic compounding. (6:6 [fn. 1]) This handbook and the DPAC Compensation Model use periodic compounding.

3. In this discussion, we'll be concerned with real discount rates unless otherwise specified. For simplicity, ignore tax considerations and assume that (1) the individual is risk-neutral and (2) saving and investment opportunities are risk-free.

4. Let d be the nominal discount rate and p the inflation rate. Then the real discount rate is

$$r = [(1+d)/(1+p)] - 1 ,$$

or

$$r = (d-p)/(1+p) ,$$

where d, i, and p are all decimal fractions (i.e., 5 percent would be expressed as 0.05). The derivation of these expressions for r parallels that for the rate of growth in real wages shown in Chapter Four. The real discount rate is often defined imprecisely as (d-r), as Black does. (6:2) Although this is strictly incorrect, it is a useful approximation as long as (1) the inflation rate is relatively small and (2) compounded rates are used cautiously, since the error also compounds. The relationships discussed in this footnote also hold between real and nominal market interest rates.

$$\frac{MU_t}{MU_{t+1}} = 1 + r, \quad (5-1)$$

where MU_t is the person's marginal utility from consumption in period t . (6:58-59) Because of the Law of Diminishing Marginal Utility, we assume that MU_t decreases as the person's consumption in period t increases, other things held constant. If the person has access to a perfect capital market, in which he can borrow or lend (save) as much as he desires at the prevailing real interest rate u , then he will tend to borrow against his future income in periods of relatively low current income, and to save (or to pay off loans) during periods of relatively high income. (6:6) Borrowing against future income causes MU_t to decrease and MU_{t+1} to increase, because consumption is reallocated from period $t+1$ to t . Equation 5-1 shows that this will decrease a person's personal discount rate r ; conversely, saving in period t would increase r .

As all individuals adjust their consumption across time periods in this manner for a given set of tastes and preferences, streams of expected income, and prevailing market interest rate u , we would expect personal discount rates to "converge toward the prevailing [market] interest rate after individuals have borrowed and saved to optimize their consumption patterns. This implies that a single personal discount rate [r] would be manifest as determined by the forces of supply and demand in the capital market." (6:9) That is, in a perfect capital market, $r = u$ for each consumer, so that Equation 5-1 can be rewritten:

$$\frac{MU_t}{MU_{t+1}} = 1 + u. \quad (5-2)$$

If a person's present allocation of consumption across time periods doesn't satisfy this equimarginal condition, he could increase his satisfaction from his expected income stream merely by reallocating his planned consumption until equality is reached. That is, in the absence of institutional constraints, he would borrow or save across periods until his real personal discount rate r equaled the real market rate of interest u . (In indifference-curve terms, satisfying the condition in Equation 5-2 means that the member's budget line is tangent to the highest indifference curve he can afford to reach, thus maximizing his satisfaction subject to his budget constraint. If that condition isn't met, the budget line crosses an indifference curve, so reallocating his consumption among time periods along his budget line would enable him to reach a higher level of satisfaction.)

Market Imperfections and Personal Discount Rates

However, imperfections that exist in the capital market drive a wedge between a person's desired and actual behaviors. In practice these institutional constraints prevent the consumer from adjusting his temporal consumption pattern until his personal discount rate equals the market rate. Two types of market imperfections lead to such a divergence: multiple interest rates and limitations on borrowing.

Multiple Rates. No single market rate of interest u exists in practice. There is one set of rates for loans (borrowing rates), and they typically exceed the rates of return earned from saving or investment (lending rates). These multiple borrowing and lending rates vary by the degree of risk, amount, maturity, and collateral of the financial instrument.⁵ In the absence of any limitations on the amount that can be borrowed or loaned at the respective sets of prevailing market rates, we would expect those borrowing rates to form lower bounds for the personal discount rate of net borrowers; saving rates should represent upper bounds for net savers. (6:9,59)

Limitations on Borrowing. However, if the lending institution takes into account such factors as the consumer's outstanding debt and current income, the lender may be unwilling to loan as much as the consumer would be willing to borrow at prevailing rates. That is, institutional constraints prevent the consumer from allocating his consumption decisions across time to the extent he might desire by not allowing him to use expected future income as collateral for current borrowing. Some extreme cases, such as young or low-income persons, may be almost completely denied access to credit, regardless of "need." At the other end of the spectrum, few if any lenders permit even their most creditworthy customers to continue borrowing at their mortgage interest rates for other consumption purposes. These constraints thwart the capital market's equilibrating mechanism, causing personal discount rates to be higher than market borrowing rates for persons who face limited access to loans. Since this access varies across individuals based on such personal characteristics as income, net worth, and other indicators of creditworthiness, we would expect to find that personal discount rates also vary across persons in practice. (6:9-10)

Implications for Personal Discount Rate Assumptions. As a result of these capital-market imperfections, we can't use observed market interest rates to measure personal discount rates directly. The theory outlined above implies that, at best, those observed rates represent lower bounds for the personal discount rate. For example, if a consumer has a mortgage, we may be able to infer that his discount rate is greater than or equal to his mortgage interest rate.⁶

5. Even a consumer who doesn't concern himself with the stock and bond markets still faces everyday examples of such multiple rates. E.g., he would pay one interest rate on a home mortgage, another one (usually higher) on a car loan, and yet another (higher still) on credit-card purchases.

6. Even such general inferences may be misleading. See the discussion on "Size of the Return" below. Hogan provides an amusing but enlightening example within the spirit of the market-rate approach: "Folklore has it that the borrowing rate on board ships in the Fleet has been 'seven for five' for years--a loan of five dollars now and repayment of seven dollars on payday. This black market rate for short term consumer loans (approximately 500%) makes many domestic loan sharks look like charitable institutions." (23:5)

EMPIRICAL EVIDENCE ON THE PERSONAL DISCOUNT RATE

If market borrowing rates give us, at best, some lower bound for the real personal discount rate, the existing empirical studies may provide only an upper bound, with a substantial range in between. Hogan's literature survey divides these studies into two categories: those of rates "implied by responses to hypothetical choices concerning current and deferred income" based on survey data; and those of rates "revealed by individuals' actual choices between current and deferred income or consumption."⁷ (23:1)

Evidence from Survey Data

Hogan concludes that, ". . . taken alone, the survey results can be considered only weakly suggestive evidence . . . that personal discount rates tend to be in the 10%-20% range, rather than, say, the 5% range." (23:6, emphasis added) The main reason for this skepticism is that, contrary to Black's incorrect description of such surveys as a revealed-preference approach (6:3,17), ". . . we can never be sure that how people respond to hypothetical survey questions is consistent with how they would behave when confronted with similar real world choices." (23:6)

Evidence from Observed Behavior

In true revealed-preference studies, the implied discount rates are based on observing the choices people actually make, so that they bear the costs of those choices, rather than on what people claim they would do under a hypothetical situation. The empirical results from these studies also vary too widely to provide much practical guidance. For purposes of discussion, we may divide the studies into two categories, based on whether they involved short- or long-term decisions.

Short-Term Decisions. One type of study is based on such relatively short-term decisions as consumption behavior in the US (e.g., the saving vs. consumption-expenditure decision) and changes in reenlistment decisions in response to variations in the Selective Reenlistment Bonus. These studies have found implied discount rates between 10 and 30 percent. (23:8-9)

Long-Term Decisions. These studies are based on decisions that are by their nature longer term and greater in dollar value than saving-consumption decisions; such choices include investing in one's human capital through education or training (which may entail forgoing current earnings and borrowing in order to finance) and choosing whether to invest in a retirement plan. Estimates of the personal discount rates implied by this type of study are slightly lower than the estimates from short-term decisions,

7. A survey of the literature on personal discount rates is beyond the scope of this handbook. The interested reader should study both Hogan's and Black's papers. Hogan's work contains an extensive bibliography and can be obtained from his office at Systems Research and Applications Corporation (SRA), Arlington, Virginia. Black's study is Appendix I to the report of the Fifth Quadrennial Review of Military Compensation. (11:--; 23:--)

ranging from 7 to 25 percent. (23:8-9) We can't determine from the available data whether this difference is statistically significant.

Variations with Age and Income

There is some agreement between the survey and the observed-behavior studies that the personal discount rate tends to decrease as age and income increase.⁸ (23:6,9) For example, Black, in his survey-based study for the Fifth Quadrennial Review of Military Compensation, found that discount rates of both officers and enlisted personnel across all services fall by approximately one-tenth of a percentage point for each additional year of service. This decline is virtually linear for officers but is curvilinear for enlisted personnel, declining more steeply for early years of service than for later ones. According to his estimates, the discount rates of Air Force officers fall from just under 12 percent at 1 YOS to just below 9 percent at 26 YOS; the rates for AF enlisted personnel in nontechnical specialties decrease from just over 14 percent at 1 YOS to just under 11 percent at 26 YOS.⁹ (6:49 [Figure 2], 50 [Figure 3]) This inverse relationship between implied discount rates and YOS is consistent with two interpretations. First, as discussed above, theory implies that discount rates should fall as income rises, and income tends to rise with age. (This might also partly explain why enlisted personnel had higher discount rates than officers at any YOS.) Second, this may be another instance of progressive selectivity: Those who remain in the service longer may be those who consider the retirement system to be an inducement to stay in, and the strength of that inducement depends on their underlying discount rates, which determine the present value of their expected retirement benefits. (6:33)

Size of the Return: An Additional Consideration

A lieutenant colonel retiring in FY 1987 after 22 YOS has an expected real income stream of approximately \$500,000 (undiscounted) from military retirement pay under the "final basic pay" system--almost \$25,000 per year.

8. Age and income are themselves positively correlated. According to studies of life-cycle earnings, real earnings tend to rise steadily with age until the mid-forties, when they peak and begin to decline moderately. As income increases, so does access to capital markets, so the theoretical model outlined above predicts that the personal discount rate would tend to fall. If, as consumer theory also predicts, consumption requirements for a given family size don't increase at the same rate as income does, then we would expect to find that older (higher-income) persons have lower marginal utilities for income, therefore lower personal discount rates than younger (lower-income) ones, other factors held constant. (6:10)

9. This doesn't mean that a service member in a given YOS uses a lower rate to discount each subsequent year's expected income. Rather, it means that a service member with, say, 15 YOS uses a lower, but constant, rate than a member with fewer YOS. In its present configuration, the DPAC Compensation Model uses a single personal discount rate across all years of service.

Would he discount such a large stream of income using the same rate as he would to discount the tradeoff between the purchase price and the operating costs of an air conditioner?¹⁰ Thaler, in hypothetical-situation experiments with college students, found that the implicit discount rate falls as the size of the "reward for waiting" increases. Based on the theory of self-control, he hypothesizes that small delayed payments may require a substantial proportional return to make the wait worthwhile--i.e., a relatively large discount rate is applied--because waiting requires effort. (5:206) If this hypothesis is correct, we'd expect service members to apply a lower discount rate to their expected retirement income than they do to decisions on consumption and on reenlistment bonuses.

Implications for ACOL Runs

Clearly, the only conclusion that we can draw from existing empirical studies of the real personal discount rate is that further research is needed, particularly on payments of magnitudes comparable to military retirement benefits. Until more definitive data are available, compensation analyses should be tested for their sensitivity to changes in the real discount rate over a range of, say, 5 to 20 percent.

10. This was the basis for one of the short-term consumer-behavior studies of implied discount rates. (23:8-9)

Chapter Six

IMPLEMENTING ECONOMIC ASSUMPTIONS IN COMPENSATION MODEL RUNS

Once we've chosen values for the long-run parameters, applying them in a Compensation Model run is straightforward in most cases. However, the responses to a few of the Model's requests for information are linked to each other by the Model's programmed logic or are constrained by its associated permanent data files. These relationships aren't always evident from the interactive questions the Model asks. In addition, several related questions are widely separated in the input sequence, which obscures the links among them.¹ In this chapter, we'll discuss those questions related to our long-term economic assumptions; then we'll examine several other questions that affect the computed ACOLs.²

APPLYING THE LONG-TERM ECONOMIC ASSUMPTIONS

One-Time Pay Changes

One of the most confusing points to novice Compensation Model users is distinguishing the long-run growth rates for military and civilian pay, which were discussed in Chapter Four, from the one-time changes the model also allows.

1. The question sequence basically has two sections: The first set of queries primarily concerns specifying the structural characteristics of the military-retirement system and the current active-duty pay table (e.g., which retirement pay base to use and whether to include the Variable Housing Allowance). In general, the second set asks for such economic assumptions as the growth and discount rates to be applied to all compensation components; this sequence also offers several options for viewing intermediate computations (the "diagnostics").

2. Appendix B contains a listing of a run from the personal-computer version of the Model, showing a basic series of questions and example responses to them. In this chapter, related questions are grouped together, regardless of their normal position in the sequence, to emphasize the links among them. Separate documentation explores many of the optional responses not covered here. (25:4-2 - 4-15)

One-Time Pay-Change Options. As Chapter Three explained, the Model reads in a permanent data set for the fiscal year we specify; that data set contains military and civilian pay data for that year. This set of options allows us to make a one-time change to that permanent data to set up the initial pay tables our long-run growth factors will be applied to. The model displays the following request:

Pay options are:
1=Current pay, no changes
2=Current pay with bonus
3=Pay change
Use Option 3 to get reallocation .

Option 1. Select this option if a permanent data set already exists containing military and civilian pay tables for the fiscal year we're computing ACOLs for and if, for an enlisted run, no Selective Reenlistment Bonuses (SRBs) are to be paid. For example, if a data set already exists that contains the FY 1987 military and private-sector pay tables, then we can compute FY 1987 ACOLs without making any further adjustments.

Option 2. This option applies to runs for enlisted personnel only. Select it if we want to pay SRBs and if pay tables for the appropriate fiscal year already exist in the permanent data base.

Option 3. This option allows us (1) to compute ACOLs for a year, even in we don't have military and civilian pay tables for it in the permanent data file; and (2) to pay SRBs based on the new military pay table, if we desire. For example, if we want to compute ACOLs for FY 1988 but we have only FY 1987 pay tables, we can use this option to create temporary 1988 pay data. If we select this option, we'll be asked later for the one-time military and civilian pay adjustments, which can be different; see "One-Time Pay-Change Amounts" below.³

Currently, the Model doesn't retain these temporary pay tables after the present run's ACOLs have been computed.⁴ Despite that limitation, this is a powerful option because it allows us to create ACOLs for any subsequent fiscal year without having to create a separate permanent data set, which is very time consuming. This is a great convenience at the beginning of a fiscal year before we've had time to update our data sets for that year's

3. Military pay tables created in this way are completely satisfactory for any ACOL computations. However, they'll differ by a few cents from official pay tables, which are adjusted so that Basic Pay and BAQ are evenly divisible by 30 for pay-proration purposes. (Try it!)

4. Each time we begin the Model's question sequence, it re-initializes all variables, so we lose all computations used in creating any previously run set of ACOLs. This means that if we first create ACOLs for nonrated officers and then want ACOLs for rated officers using exactly the same parameters, we must re-enter all the data from the beginning, including the one-time pay changes.

pay raises (if any). It also allows us to experiment with different possible raises for any future year. For example, we could create pay tables for, say, FY 1989 if we wanted to compute ACOLs for that year. Given the FY 1987 pay table and our assumed pay raises for FYs 1988 - 1989, we merely compound the latter two raises and use the resulting percentage growth factor in our response to the "One-Time Pay-Change Amount" question discussed below. (Recall: ACOLs are expressed in nominal, base-year dollars. In this example, FY 1989 becomes the base year, as explained below.)

Reallocation. Option 3 allows us the flexibility to handle military pay raises that don't raise all pay elements (Basic Pay, BAS, BAQ, and VHA) by the same percentage across-the-board. Such raises occurred in FYs 1977, 1978, and 1981. (10:15) This feature can also be used for two other special cases: (1) if either BAQ or VHA isn't raised by the same percentage as Basic Pay, as the current VHA system allows; and (2) if some pay grades receive different pay raises than others, as occurred for "career" members in FY 1981.⁵ (10:10)

One-Time Pay-Change Amounts. If Option 3 was selected above, the Model will later ask for the one-time percentage increases for civilian and military pay.

Civilian. The Model asks:

Do you want to raise civilian pay? (1=Yes,0=No) .

If we answer "1" (i.e., "yes"), the Model then asks:

Enter civilian pay raise % .

Entering "4.7" yields a one-time pay raise of 4.7 percent to the previously existing civilian pay table.

Military. The Model asks:

If pay change is a percent across-the board
for Basic Pay, BAQ & BAS,
enter 1 followed by the % change, else enter 0 .

E.g., entering "1,3" in response to the last question creates a temporary military pay table containing a one-time, across-the board pay raise of 3 percent.⁶ Entering "0" elicits a sequence of questions that allows us to give different pay raises to different ranks or pay elements.

5. The term "reallocation" comes from the 1977 legislation authorizing the President to allocate overall increases in military pay among the different pay elements "on other than an equal percentage basis." (10:10)

6. These responses illustrate the Model's convention for entering percentage increases. However, there is an important exception the Model doesn't warn us about: If "0" is selected, the convention changes for

Long-Run Wage and Price Growth

Regardless of whether we've used a one-time pay raise, we'll always be asked for our long-range wage and price growth assumptions with the following request:

Please enter economic assumptions

1-Assume zero CPI, no wage growth

2-Assume wage growth and inflation .

Option 1. This option means that prices and nominal wages never change. Hence, real wages are also constant. ("Zero CPI" actually means no growth in the CPI.)

Option 2. This is the option we use in almost all cases. The Model will then ask us to

Enter CPI, mil wage growth, civ wage growth %s .

(Here again, we're being asked for the CPI growth rate, not the value of the index itself.) Say that, based on the consensus economic forecasts, we expect an inflation rate of 4 percent and growth in nominal civilian wages of 5 percent over the long run. Furthermore, say we're assuming military and civilian pay will grow at the same rate in the long run (i.e., relative pay will remain at the level that exists in the base-year pay table, after any one-time adjustments). Then, we would enter "4,5,5" in response to this question; this would result in real wage growth of about 1 percent per year (0.96 percent).

ACOLs and Base-Year Nominal Dollars

We need to digress from the sequence of interactive questions here to make an important and related point that couldn't be explained until the one-time and long-run pay raise features were fully understood: ACOLs computed by the Compensation Model are by definition expressed in the base year's nominal dollars. If we use the pay table read from the permanent data set without any of the one-time raises just described, then the year corresponding to that pay table is the base year for that set of ACOLs. But if we create a new pay table for a subsequent year using one-time pay-change option number 3, that year becomes the base year, and the resulting ACOLs will be in that year's nominal dollars. The long-term growth factors described above are then applied to the base-year table, and the resulting incomes are deflated and discounted back to the base year. (E.g., for the above example in which we created a temporary 1989 pay table, the resulting

answers to some of the subsequent questions relating to this option. Any entry greater than or equal to 1 is assumed to be a dollar value, while any entry less than 1 is taken as a percentage (e.g., entering 0.05 is interpreted as 5 percent). This allows us to specify either percentage changes or absolute dollar-value changes to the various pay elements. (12:2-3,5-20)

ACOLs would be in 1989 dollars.) Note that ACOLs from different years must be deflated to the same year's dollars before being compared with each other.⁷

Discount Rate

If we've assumed long-term wage growth and inflation, the Model will next ask us to

Enter nominal discount % .

Entering "9" in response would result in a real discount rate of approximately 5 percent (4.8 percent), assuming the 4-percent inflation rate we used above. On the other hand, if we've assumed no long-run wage or price growth, the Model will ask for the real discount rate. Actually, the Model always uses the real discount rate in its computations; if we've assumed price and wage growth, it just deflates the nominal discount rate. (After the ACOLs are displayed for a run, the model also displays many of the parameters used for that run; one of these is $[1/(1+d)]$, where d is the nominal discount rate.)

Cost-of-Living Adjustments

If we're allowing wage and price growth, the Model next directs us to

Enter COLA %s for mil, then civ .

This allows us to specify the cost-of-living adjustments (COLAs) to be applied to military and civilian retirement pay.⁸ With an assumed 4-percent inflation rate, responding "4,4" to this question fully adjusts retirement pay for inflation. If the military COLA is less than the inflation rate specified previously, the Model asks a follow-up question to allow restoral of full COLA at a later age.

7. When we use ACOLs from the Compensation Model in estimating new retention rates for DPAC's force-structure simulation models, the ACOLs must be expressed in 1967 dollars. The officer model's preprocessor does this conversion automatically, but it must be done by hand or by a separate computer program for the enlisted models.

8. Civilian retirement pay isn't used in the ACOL computation; because that term shouldn't change from one military compensation-policy scenario to the next for a given career path, it is assumed to "wash out" in comparing two sets of ACOLs. (In addition, when the Model was written, the available data weren't sufficient to construct a formula for retirement benefits under an "average" private-sector retirement plan.) However, the above assumption isn't correct under two conditions that occur frequently in practice: (1) if the YOS in which the maximum ACOL occurs changes, since the career path may then change; and (2) if the regression model assumes tastes for service have a nonlinear distribution, such as the logistic function used in DPAC's retention models (the inaccuracies in this case may be negligible).

SOME RELATED QUESTIONS

Retirement Eligibility

Near the beginning of the question sequence, the Model always asks us to

Enter YOS of retirement eligibility .

The usual response to this question is "20"--the minimum number of completed YOS required for retirement eligibility under current law. The Model will actually accept any positive number here, which might be interpreted to mean that we should be able to experiment with ACOLs for various different retirement-eligibility points. However, such ACOLs wouldn't be technically correct, because the force-structure distribution (the probability of being in a given grade during a given YOS), which the Model reads from the permanent data set for the appropriate fiscal year, depends on historical retention and retirement patterns. Those patterns in turn depend on the current retirement eligibility point of 20 YOS; this is especially true of the years beyond 20 YOS. In order to experiment with alternative retirement points, we would have to manually adjust the force-distribution matrix accordingly before running the ACOL model, and such an adjustment would be at best an educated guess.

Basic Military Compensation Table

If we answer "yes" to the question

Want to see BMC table?

then a BMC or RMC table by grade and YOS will be displayed. If we selected the option to pay VHA, then the table contains RMC. (Caution: The table is always labeled "BMC," whether VHA is paid or not.) (12:5-8)

BIBLIOGRAPHY

A. REFERENCES CITED

Books

1. Arguden, R. Yilmaz. Personnel Management in the Military: Effects of Retirement Policies on the Retention of Personnel. Project AIR FORCE Report R-3342-AF. Santa Monica, CA: Rand Corporation, 1986.
2. Clayton, Gary E., and Christopher B. Spivey. The Time Value of Money. Philadelphia: W. B. Saunders Company, 1978.
3. Reynolds, Lloyd G. Labor Economics and Labor Relations, 7th ed. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1978
4. Warner, John T. Military Compensation and Retention: An Analysis of Alternative Models and a Simulation of a New Retention Model. Center Research Contribution (CRC) 436. Alexandria, VA: Center for Naval Analyses, 1981.

Article

5. Thaler, Richard. "Some Empirical Evidence on Dynamic Inconsistency." Economics Letters, Vol. 8 (1981), pp. 201-207.

Official Documents

6. Black, Matthew. "Personal Discount Rates: Estimates for the Military Population." Attachment 3 to Appendix I of US Government: Office of the Secretary of Defense, Fifth Quadrennial Review of Military Compensation, Vol. IB: Supporting Appendixes to Uniformed Services Retirement System (H-N). Washington, DC: Government Printing Office, January 1984.
7. US Government: Department of Labor. Bureau of Labor Statistics. BLS Handbook of Methods, Vol. 1. Bulletin 2134-1. Washington, DC: Government Printing Office, December 1982.
8. -----: Executive Office of the President. Council of Economic Advisers. Economic Report of the President. Washington, DC: Government Printing Office, February 1985.

CONTINUED

9. -----: Executive Office of the President. Council of Economic Advisers. Economic Report of the President. Washington, DC: Government Printing Office, February 1986.
10. -----: Office of the Secretary of Defense. Military Compensation Background Papers, 2nd ed. Washington, DC: Government Printing Office, July 1982.
11. -----: Office of the Secretary of Defense. Fifth Quadrennial Review of Military Compensation, Vol. I: Uniformed Services Retirement System. Washington, DC: Government Printing Office, January 1984.

Unpublished Materials

12. US Department of the Air Force: HQ United States Air Force (DP). "The Compensation Model: A User's Guide," background paper (by Patricia Beymer). Washington, DC: HQ USAF/DPAC, undated.
13. -----: HQ United States Air Force (DP). "Federal Civilian Pay Gap and Military Pay Gap," background paper. Washington, DC: HQ USAF/DPXE, undated.
14. -----: HQ United States Air Force (DP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Personnel, Headquarters USAF: 1 January 1977 - 30 June 1977," unit history. Washington, DC: HQ USAF/DPX, undated.
15. -----: HQ United States Air Force (DP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Personnel, Headquarters USAF: 1 July 1977 - 31 December 1977," unit history. Washington, DC: HQ USAF/DPX, undated.
16. -----: HQ United States Air Force (DP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Personnel, Headquarters USAF: 1 January 1978 - 30 June 1978," unit history. Washington, DC: HQ USAF/DPX, undated.
17. -----: HQ United States Air Force (DP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Personnel, Headquarters USAF: 1 July 1978 - 31 December 1978," unit history. Washington, DC: HQ USAF/DPX, undated.

CONTINUED

18. -----: HQ United States Air Force (DP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Personnel, Headquarters USAF: 1 January 1979 - 30 June 1979," unit history. Washington, DC: HQ USAF/DPX, undated.
19. -----: HQ United States Air Force (DP). "Qualitative Comparison of Retirement Studies and Programs," background paper. Washington, DC: HQ USAF/DPX, undated.
20. -----: HQ United States Air Force (MP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Manpower and Personnel, Headquarters USAF: 1 July 1980 - 31 December 1980," unit history. Washington, DC: HQ USAF/MPX, undated.
21. -----: HQ United States Air Force (MP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Manpower and Personnel, Headquarters USAF: 1 January 1981 - 30 June 1981," unit history. Washington, DC: HQ USAF/MPX, undated.
22. -----: HQ United States Air Force (MP). "History of the Directorate of Personnel Plans, Deputy Chief of Staff, Manpower and Personnel, Headquarters USAF: 1 January 1982 - 30 June 1982," unit history. Washington, DC: HQ USAF/MPX, undated.
23. US Government: Office of the Assistant Secretary of Defense for Force Management and Personnel. "Implied Personal Discount Rates: Evidence from the Literature," background paper (by Paul F. Hogan). Washington, DC: OASD/FM&P, 1983.
24. "Functional Description of the Compensation Model, Data Base Base Build and EPOM Programs for the United States Air Force Manpower and Personnel Analysis Center," revised ed. Contract report. Landover, MD: Science Management Corporation, July 1985.
25. "Users (sic) Manual for the Compensation Model, Data Base Build and EPOM Programs for the United States Air Force Manpower and Personnel Analysis Center," revised ed. Contract report. Landover, MD: Science Management Corporation, August 1985.

CONTINUED

B. RELATED SOURCES

Official Documents

- Cooper, Richard V. L., "Military Retirees' and Separates' Post-Service Earnings," Appendix Q of US Government: Office of the Secretary of Defense, Fifth Quadrennial Review of Military Compensation, Vol. IC: Supporting Appendixes to Uniformed Services Retirement System (P-Q). Washington, DC: Government Printing Office, January 1984.
- Smoker, Roy E., Major, USAF. "Annualized Cost of Leaving Model (ACOL)," Appendix I of US Government: Office of the Secretary of Defense, Fifth Quadrennial Review of Military Compensation, Vol. IB: Supporting Appendixes to Uniformed Services Retirement System (H-N). Washington, DC: Government Printing Office, January 1984.
- US Government: Office of the Assistant Secretary of Defense for Force Management and Personnel. Selected Military Compensation Tables: October 1985 Pay Rates. Washington, DC: OASD (FM&P), October 1985.
- Office of the Secretary of Defense. Fifth Quadrennial Review of Military Compensation, 3 vols. Washington, DC: Government Printing Office, January 1984.

Unpublished Materials

- Borjas, George J. and Finis Welch. "The Post-Service Earnings of Military Retirees--Phase I: Re-Analysis of the Cooper Study." Contract report. New York: The Conference Board, Inc., April, 1984.
- "The Post-Service Earnings of Military Retirees: Evidence from the Air Force." Contract report. New York: The Conference Board, Inc., July, 1965.
- "Program Maintenance Manual for the Compensation Model, Data Base Base Build and EPOM Programs for the United States Air Force Manpower and Personnel Analysis Center," revised ed. Contract report. Landover, MD: Science Management Corporation, August 1985.

APPENDICES

APPENDIX A--Glossary	60
APPENDIX B--Example Run of DPAC Compensation Model	61

GLOSSARY

ACOL	Annualized Cost of Leaving (the service)
AHE	Average Hourly Earnings (index)
BLS	Bureau of Labor Statistics
BMC	Basic Military Compensation
CPI-U	Consumer Price Index for All Urban Consumers
DOPMS	Defense Officer Personnel Management System
ECI	Employment Cost Index
EPAS	Enlisted Policy Analysis System
EPOM	Enlisted Program Objective Memorandum Model
PATC	Professional, Administrative, Technical, and Clerical workers' wage index
PVCOL	Present Value of the Cost of Leaving (the service)
RMC	Regular Military Compensation
SRB	Selective Reenlistment Bonus
YOS	Year(s) of Service

Appendix B

SAMPLE RUN OF DPAC COMPENSATION MODEL
(PERSONAL COMPUTER VERSION)

NOTES

```
comps
ENTER INPUT DATA FILE NAME:ofy85.dat
ENTER OUTPUT DATA FILE NAME:test.dat
WANT TO RUN CURR RETIREMENT ONLY? (1=YES,0=NO)

1

DO YOU WANT VESTING?

0

ENTER YOS OF RETIREMENT ELIGIBILITY

20
DO YOU WANT TO CHANGE THE RETIREMENT MULTIPLIER?

0

PAY OPTIONS ARE:
  1=CURRENT PAY, NO CHANGES
  2=CURRENT PAY WITH BONUS
  3=PAY CHANGE
USE OPTION 3 TO GET REALLOCATION

3

WANT TO PAY VHA?

1

ENTER 1=OFFICER OR 2=ENLISTED

1

SELECT RATED STATUS:
  1=NONRATED
  2=NAVIG
  3=PILOT
```

(First three lines are unique to PC version.) Model's prompts are capitalized; user's responses are in lower case for readability only. "ofy85.dat" is the officer data set for FY 85, the latest year available on the PC version as of this writing.

(Unique to PC version.)

By selecting Option 3, we'll be able to create military and civilian pay tables for FY 86 (or any other year) later in the run.

1

PAY ENGINEER BONUS?

0

WANT SOCIAL SECURITY OFFSET?

0

SELECT RETIREMENT BASE:

1=FINAL BASIC PAY

2=HI 2-YR AVG BASIC PAY

3=HI 3-YR AVG BASIC PAY

4=HI 2-YR AVG BMC

1

WANT A CONTRIBUTORY RETIREMENT SYSTEM?

0

PLEASE ENTER ECONOMIC ASSUMPTIONS

1-ASSUME ZERO CPI, NO WAGE GROWTH

2-ASSUME WAGE GROWTH AND INFLATION

2

ENTER CPI, MIL WAGE GROWTH, CIV WAGE GROWTH %S

4,5,5

ENTER NOMINAL DISCOUNT %

9

ENTER COLA %S FOR MIL, THEN CIV

4,4

WANT TO SEE A DIAGNOSTIC PRINT? (1=YES,0=NO)

0

DO YOU WANT TO RAISE CIVILIAN PAY? (1=YES,0=NO)

1

ENTER CIVILIAN PAY RAISE %

4.7

WANT TO SEE CIVILIAN PAY?

These are the long-term growth rates.

These two questions allow us to raise civilian pay one time; in this case, we create a temporary FY 86 pay table for civilians by increasing their FY 85 table by 4.7 percent.

0

IF PAY CHANGE IS A PERCENT ACROSS-THE-BOARD
FOR BASIC PAY, BAQ & BAS,
ENTER 1 FOLLOWED BY THE % CHANGE, ELSE ENTER 0,0

1,3

ENTER 1 (YES) OR 0 TO CHANGE FLIGHT PAY

0

WANT TO SEE PAY ELEMENTS?

0

WANT TO SEE BMC TABLE? (1=YES,0=NO)

Here, we give a one-time,
across-the-board military
pay increase of 3 per-
cent, which creates a
temporary FY 86 pay table
based on the permanent
FY 85 data set.

ANNUALIZED COST OF LEAVING THE AIR FORCE
 UNDER THE CURRENT RETIREMENT SYSTEM
 FOR OFFICER PERSONNEL

COMPLETED YRS SVC	PVCOL	ACOL
1	187291.	12111.
2	200947.	13235.
3	211064.	14171.
4	218514.	14971.
5	222522.	15577.
6	228645.	16380.
7	235541.	17300.
8	244625.	18457.
9	254959.	20227.
10	267612.	22599.
11	280850.	25414.
12	297541.	29099.
13	312523.	33348.
14	328521.	39358.
15	343951.	47532.
16	442502.	84170.
17	452702.	111265.
18	461733.	164632.
19	470850.	324468.
20	156250.	31282.
21	138934.	38585.
22	104775.	16778.
23	96988.	18076.
24	89057.	21112.
25	82111.	31647.
26	49507.	15051.
27	43914.	18852.
28	43558.	36028.
29	4639.	4862.
30	0.	0.

The Model produces this display at the end of its run. The table shows the maximum value of $PVCOL_{t,n}$ and $ACOL_{t,n}$ for each completed YOS t , for $t=1, 2, \dots, 30$.

For example, a member completing YOS 4 can leave "now" or at the end of YOS 5, 6, ..., or 30. Therefore, he has a $PVCOL_{4,j}$ and an $ACOL_{4,j}$ value for each of those years, $j=5, 6, \dots, 30$. Of those values, \$218,514 is the maximum PVCOL and \$14,971 the maximum ACOL.

(Recall that the maximum ACOL for YOS t is not necessarily the annualized value of the PVCOL for year, as explained in Chapter Three, so there is no systematic relationship between the PVCOLs and ACOLs in the table.)

NOTE--RUN PARAMETERS ARE
 INFLATION RATE= .04000
 WAGE GROWTH RATE (MIL) = .05000
 (CIV) = .05000
 1/1+DISCOUNT RATE = .95413
 INTEREST RATE ON EW = .00000
 RETIREMENT BASE = 1
 WHERE 1 = FINAL BASIC
 2 = HI-2 BASIC
 3 = HI-3 BASIC
 4 = HI-2 BMC
 AGE 2ND TIER PAYMENTS BEGIN 0
 RETIREMENT MULTIPLIER = .02500

INDEX

A

- ACOL (*see also* ACOL Model)
 - and fallacy of composition, 17
 - and PD_a , 16
 - and retention decision, 16, 18
 - as proxy for relative compensation, 16, 18
 - derivation, 14-15
 - expected value, 26
 - formula and definition, 15
 - individual vs. cohort, 17
 - interpretation, 5, 15
 - logistic distribution, 18
 - maximum ACOL assumption, 16-19
 - maximum value as threshold, 18
 - maximum value vs. maximum PVCOL, 16, 20
 - misinterpretation, 17
 - non-homogeneity, 20
 - properties, 19, 20
- ACOL model, 12 (*see also* ACOL)
 - data base, 23, 25, 50
 - data base--errors, 25
 - data set documentation, 23
 - disadvantages, 21-22
 - DPAC implementation, 23-26
 - properties, 21, 22
- age
 - correlation with income, 47
 - effect on discount rate, 47
 - link with YOS, 23
- age-earnings profile, 23
- All-Volunteer Force (AVF), 33-35
- alternative cases, 39, 40
- Annualized Cost of Leaving, *see* ACOL and ACOL model
- annuity, 15
- Arguden, R. Yilmaz, 1, 5, 17, 18, 21, 22
- average hourly earnings (AHE), 32-33, 36-37
- Aviation Career Incentive Pay (ACIP), 23

CONTINUED

B

base cases
 other wage- and price-growth assumptions for, 38
 types, 38
 wage- and price-growth assumptions for, 38
base year, 23, 52
Basic Pay, 24, 50-52
Basic Allowance for Quarters (BAQ), 24, 50-52
Basic Allowance for Subsistence (BAS), 24, 50-52
Basic Military Compensation (BMC), 24, 54
 table created by Compensation Model, 54
Beymer, Patricia, 2-3
Black, Matthew, 42, 43, 46, 47
bonuses, see Selective Reenlistment Bonuses
borrowing rate, 45
 in the Fleet, 45
Bureau of Labor Statistics (BLS), 35

C

capacity effect, 31
capital market
 imperfections, 44
 imperfections--implications for personal discount rate, 45
 limitations on borrowing, 45
 multiple rates, 45
 perfect, 43, 44
career paths, 6
censoring of tastes, see self-selection
Chase Econometrics, 37
civilian pay, 8, 23
 one-time increases, see pay, changes
 penalty for additional YOS, 26
COLA, 23, 53
compensation differential, see compensation, relative
compensation, relative, 1, 2, 5-6, 10, 12-13, 21-23, 28
 Law of Supply, 33
 assumptions, 37, 52
 expected case, 39
 impact on ACOL, 36
 other base cases, 39

CONTINUED

status quo, 39
trend, 34, 36
Compensation Model, history of in DPAC, 2
compensation policy, 1
 importance of discount rate for, 41
compounding, continuous vs. discrete, 43
consensus forecast, 37
 implementing, 52
Consumer Price Index (CPI-U), 27, 35
conventions for receiving and discounting income, 7-8
cost of leaving, 10 (see also ACOL and PVCOL)
cost-of-living adjustment, see COLA

D

Data Resources, Inc. (DRI), 37
Defense Officer Personnel Management System (DOPMS), 3, 7
discounting conventions, 8
discount rate, 23, 27, 41-48
 and value of retirement benefits, 42
 assumptions, 53
 defined, 43
 effect of size of return, 47
 empirical evidence, 46-48
 implications of empirical data for ACOL assumptions, 48
 survey data, 46
 variation with age and income, 47

E

econometric models, 2
econometric-forecasting firms, 37
economic assumptions, 27-40
 discount rate, 41, 48
 implementing, 49
economic rent, 13
elasticities, 3, 25-26, 37
eligibility to separate, 7
Employment Cost Index (ECI), 35, 36
Enlisted Policy Analysis System (EPAS), 3

CONTINUED

EPOM (enlisted-force policy-analysis model), 7
expected case, wage- and price-growth assumptions, 38
expected value of PVCOL and ACOL, 26

F

factor shares (in national output), 29
 (see also labor's share)
fallacy of composition, 17
family size distribution, 26
Fifth Quardrennial Review of Military Compensation (QRMC), 43, 46, 47
flight pay, see Aviation Career Incentive Pay
force distribution, 24, 26
force-structure simulation models, see simulation models
forward-looking model, 11, 21
fringe benefits, 5, 36

G

givebacks (of wages and benefits), 32
Gramm-Rudman-Hollings, 34, 39
Greenberg, Harvey (Major), 3
growth rate
 prices (long-run), 23, 27-29, 52
 real wages (long-run), see real wage growth
 retired pay, see COLA
 wages (long-run), 23, 52

H

high year of tenure, 8
Hogan, Paul F., 45, 46

I

income
 correlation with age, 47
 effect on discount rate, 47
indifference (between military service and civilian career), 12
indifference-curve analysis, 44
inflation, 2 (see also growth rate, prices)
interest rate, see borrowing rate and lending rate

CONTINUED

L

labor supply, determinants, 5
labor's share, 28, 29
 trend, 30, 31
lending rate, 45
lifestream earnings, 6, 9
limitations on borrowing, 45
logistic distribution, 18, 21, 26
long-run growth rates, see growth rate
loss rate, 6 (see also retention, rate(s))

M

marginal member, 18
marginal utility, 43, 44
 Law of Diminishing MU, 44
maximum-regret model, 11, 22
military pay, 8 (see also growth rate)
 caps, 2
 one-time increases, see pay, changes
 raises, 2
Military Retirement System, see retirement pay
MODC7, 3
Monaco, S. J. (Lt Col), 2, 3
mortality rates, 24, 26
multiple interest rates, 45

O

opportunity cost, 5, 15
"optimal time to leave," 11, 17

P

PATC, 35, 36
pay
 changes--one-time options, 49-51
 civilian, 25
 creating temporary tables for future years, 50
 elements, 24
 gap, see compensation, relative

CONTINUED

growth rate, 21 (see also growth rate, wages and real wages)
measures of, 24
past policies, 11, 21
reallocation (among pay elements), 51
 $PD(y)$ (indifference level of pay differential), 12
 pd_a (expected actual compensation differential), 12
percentage increases, convention for entering, 51
personal discount rate, see discount rate
pilot hires, 3
policy importance of discount rate, 41
post-service career earnings, 9
post-service earnings, 26
present value, 6, 8, 9, 15, 22, 42
 Compensation Model's convention, 8
 convention for reference point, 8
 of annuity factor, 15
Present Value of Cost of Leaving, see PVCOL
President's Commission on Military Compensation (PCMC), 2
President's Pay Agent, 35
probability distribution of tastes for service, 17
probability of living, see mortality rates
productivity
 and relationship to real wage growth, 30, 31
 long-run growth, 32
 productivity growth, relationship to real wage growth, 28, 29
Professional, Administrative, Technical, and Clerical workers' wage
 index, see PATC
promotions, probability, 24
PVCOL, 6, 10 (see also PVCOL model)
 and taste factor, 14
 as proxy in regression equation, 11
 expected value, 26
 interpretation, 5
PVCOL Model, 1, 12, 21 (see also PVCOL)
 definition, 10
 disadvantages, 11

Q

QRMC, see Fifth QRMC

CONTINUED

R

random shocks, 6, 22
rates of growth, *see* growth rate
real discount rate, *see* discount rate
real wage growth, 27-33, 37-40
 defined, 29
 growth rate--approximation, 30
 growth rate--incorrect definition, 30
 growth--and standard of living, 33
 growth--data, 35
 long-run, 32, 52
 relationship to inflation rate, 30
 relationship to productivity growth, 30, 31
 rules of thumb, 30
reallocation of consumptions across time periods, 43-45
reallocation of pay, *see* pay, reallocation
reasonableness tests, 27
Regular Military Compensation (RMC), 24, 54
relative compensation, *see* compensation, relative
relative earnings, *see* compensation, relative
relative wages, 28, 33-40 (*see also* compensation, relative)
retention, 1, 21
 and taste for service, 13
 decision, 22
 effect of past pay policies, 7
 effect of past values of explanatory variables, 7
 expected rate (formula), 19
 models, 1-3, 5, 22
 models--types of, 1
 patterns, 6, 10
 rate(s), 1, 3, 6
retirement pay, 2, 5, 8-9, 22-23, 41-42
 civilian--in ACOL computation, 53
 eligibility, 54
return to leaving, 10, 14
return to staying, 8, 9, 10
revealed preference, 46
reward for waiting, 48
Reynolds, Lloyd G., 30-31
rules of thumb, 30

CONTINUED

S

Science Management Corp., 23, 25
Selective Reenlistment Bonus(es) (SRB), 22, 46, 48, 50
self-control, theory of, 48
self-selection, 6, 11, 22
simulation models, force-structure, 3, 53
Social Security taxes, 24
standard of living, relationship to real wage growth, 33
status quo, wage- and price-growth assumptions, 38
Supply
 changes in quantity supplied, 33-34
 Law of, 33-34
 of labor--determinants, 5

T

taste for service, 7, 12, 22
 and expected income differential, 13
 and retention decision, 13
 assumed constant, 14
 effect of working conditions on, 12
 negative, 13
 neutral, 13
 positive, 13
 role in ACOL model, 19
 vs. distaste, 13
tax advantage (of nontaxed allowances), 24-25
 DPAC implementation of, 24-25
 property of, 25
taxes, 25
term of service, 7
Thaler, Richard, 48

U

unemployment rate, 2, 3, 7, 34
unit labor costs, 29

CONTINUED

V

Variable Housing Allowance (VHA), 24
vesting, 2
Vetterlein, Jon (Major), 3, 34

W

wage growth, nominal, 29 (see also real wage growth)
wages, real, 27 (see also real wage growth)
Warner, John T., 1, 5, 7, 9, 17, 21
Wharton Econometrics, 37

Y

year(s) of service (YOS), 7
YOS-age link, 23
 $y_{t,p}$ (taste factor), 12

**DAT
ILM**