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Defense Manpower Policy: Presentations from the 1976 Rand Conference on Defense Manpower

Edited by Richard V. L. Cooper

A Report prepared for

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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are given
Selected presentations from the 1976 Rand Conference on Defense Manpower, a DoD-wide effort to bring together researchers and policymakers to discuss important defense manpower policy problems. The nineteen papers reproduced in this volume cover four broad policy areas: (1) the demand for manpower, including both numbers and types of personnel needed and how these requirements are affected by various factors; (2) military manpower procurement in a volunteer environment; (3) other aspects of the military manpower management problem, including training, promotion, and compensation; and (4) economic and social effects associated with defense manpower. One of the primary purposes of the Conference was to exchange information and ideas and to begin to establish research priorities. These papers, which highlight problem areas and suggest potential solutions, offer a useful first step in structuring the overall defense manpower policy problem. (JDL)

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PREFACE

With total budget costs in excess of $60 billion per year, defense manpower is second only to Social Security in terms of Federal spending. This alone makes defense manpower one of the most important public policy concerns in the nation. Yet the policy aspects of defense manpower go far beyond these cost figures; defense manpower is not only at the very core of the nation's defense posture, it is also an important factor in the country's economic and social policy.

In view of this, The Rand Corporation, in February 1976, hosted the Rand Conference on Defense Manpower, sponsored by the Human Resources Research Office (now the Cybernetics Technology Office) of the Defense Advanced Research Projects Agency (ARPA). The purpose of this conference—the first DoD-wide effort of this sort—was to bring together a wide array of researchers, policymakers, and others concerned with the development and implementation of improved defense manpower policy. It was hoped that such a forum would offer a useful first step in furthering the exchange of information and ideas among the many individuals and organizations working on defense manpower issues and problems.

This book contains selected presentations from the Rand Conference on Defense Manpower. Because of space limitations and to keep this volume focused on a general theme, not all the papers presented could be published. (Appendix A provides the complete Conference agenda.) Nevertheless, the papers included here provide a reasonably good sampling of the topics and issues addressed at the Conference.

ACKNOWLEDGMENTS

As the organizer of the Rand Conference on Defense Manpower and the editor of this volume, I am deeply indebted to many individuals. Special thanks go to Dr. Austin Kibler, formerly Director of the Human Resources Research Office of the Defense Advanced Research Projects Agency, for his strong support and for first suggesting that such a conference be held. The authors of the papers presented here of course deserve particular mention, as their efforts provided much food for thought for all who attended. I would also like to thank each of the session chairmen and discussants. Each of the attendees, and I in particular, owe a special debt of gratitude to Toby Brown for efficiently organizing the many functions before, during, and after the Conference. Finally, but by no means least, I would like to thank Janet DeLand and Helen Turin for their expert editorial and production assistance in putting together this proceedings volume.

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PART III: PERSONNEL MANAGEMENT

PART IV: MANPOWER AND SOCIAL POLICY

INTRODUCTION

Richard V.L. Cooper
The Rand Corporation

Defense manpower, always an important part of public policy, has assumed even greater importance in recent years. The end of the draft, skyrocketing manpower costs, and a host of other factors have all served to make defense manpower one of the key concerns in the Pentagon and on Capitol Hill. Accordingly, the purpose of this book is to shed some light on some of the major issues that comprise this important public policy problem.

The importance of defense manpower as a policy problem stems, in large part, simply from its magnitude. The defense manpower system includes some 4 to 5 million people, depending on who is counted. This includes more than 2 million active duty uniformed personnel, nearly 1 million reservists, about 1 million civilians on the defense payroll, and some 500,000 other civilian personnel working indirectly for the Department of Defense (DoD). Defense manpower is important not only in terms of these numbers of personnel, however, but also in terms of costs, for the defense manpower system is second only to Social Security as an area of Federal spending. The costs of defense manpower have increased from about $25 billion in 1964 to $60 billion in 1976. In fact, combined with its capital stock of some $400 billion, the DoD is the largest single employer of resources in the nation.

Concern for defense manpower of course transcends these aggregate strength and cost measures. The raising and maintaining of a military force is always a vital part of a nation's public policy, and this is especially true for the United States, given the long-standing American tradition of maintaining civilian control over the military. The relevance of defense manpower to the public policy decision process is also manifested in the ways in which military experience shapes the attitudes and mores of those who have served. Every year, hundreds of thousands of young men and women join the military, and their experiences in the military must surely have a significant effect on their future lives—and, hence, on society in general.

In short, defense manpower is important not only because of its role in maintaining a strong national defense but also because of the subtle ways in which the defense manpower system affects U.S. defense, economic, and social policies. A better understanding of the defense manpower problem can therefore only lead to improved pubic policy decisionmaking.

STRUCTURING THE MANPOWER PROBLEM

Because of the sheer size of the defense manpower system and the breadth of effects caused by defense manpower policy, the manpower problem must first be structured into meaningful, but manageable, pieces. As a first step, let us consider the defense manpower system in terms of its major components, as shown in Fig. 1. At the most aggregate level, defense manpower can be categorized into uniformed and civilian personnel, since these two elements are likely to differ in important ways such as how they are procured and retained, how they are used, and how they are managed.

Civilian DoD personnel, can, in turn, be divided into those who are employed by civilian firms under contract to the military (i.e., contract hires, such as civilian employees of private-sector firms engaged in the provision of maintenance services) and those who are employed by the government (i.e., government hires). There are two main groups of government hires: appropriated-fund employees and nonappropriated-fund employees. Nonappropriated-fund personnel are those civilians whose wages and salaries are not paid out of Congressionally appropriated funds. For example, employees of military commissaries and Post Exchanges are paid out of the funds generated by the sale of goods and services, not out of funds appropriated by the Congress. Appropriated-fund civilians can be further disaggregated according to whether they are directly hired by the DoD or indirectly hired (i.e., foreign nationals working on U.S. installations abroad whose costs, though actually paid by the host nation, are reimbursed by the U.S. military). Finally, direct hires can be disaggregated into general schedule and "other" (generally, wage board).

The reason for this rather lengthy categorization is simply that the policies and procedures used to govern these different groups and the data and methods used to analyze them are in many cases quite varied. As a policy problem, then, though it is important not to lose

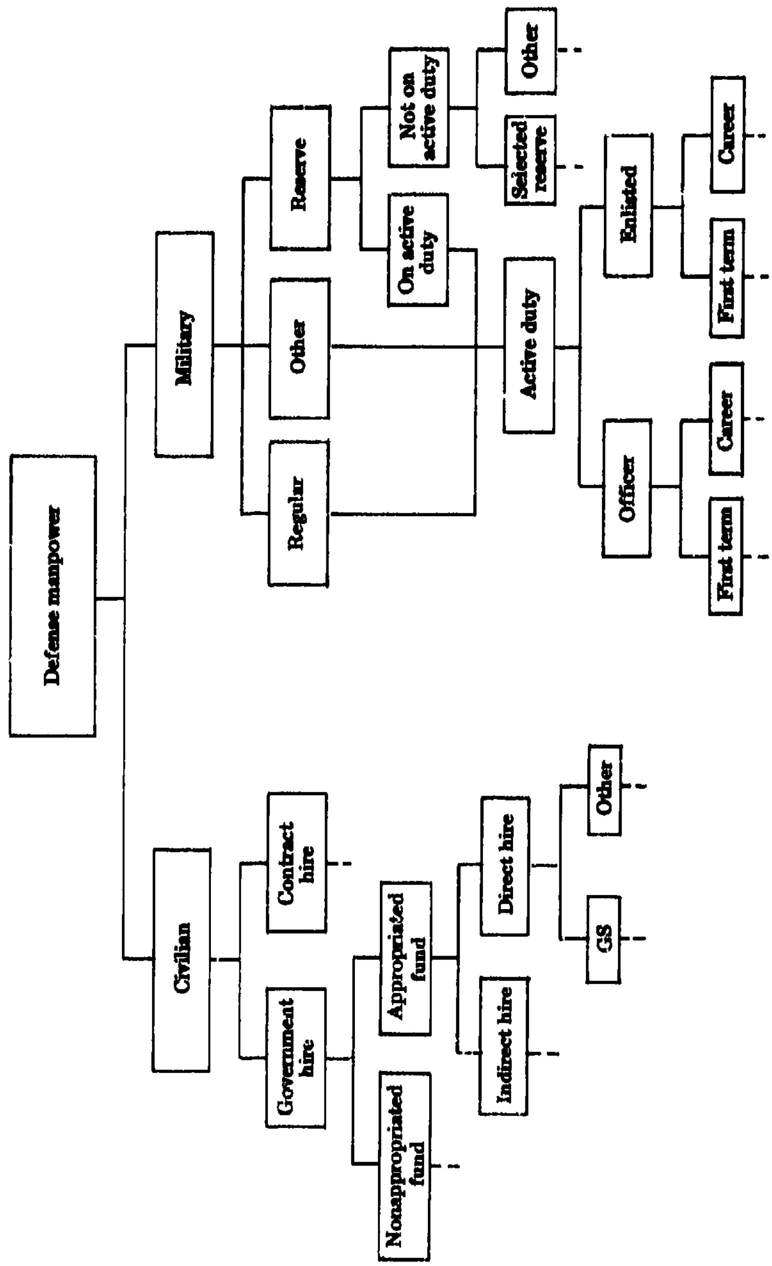

Fig. 1—Defense manpower system

sight of the larger picture made up by the individual parts, these parts often require different data, different modes of analysis, and different policy solutions—and hence must be viewed accordingly.

The military personnel system can be disaggregated in a similar fashion. For example, military personnel can be categorized into the active duty and reserve forces. (Note, though, that there are some "reservists" on active duty.) Military personnel, whether regular or reserve, can be further classified as either officers or enlisted members. For the most part, the officer corps has the primary management and leadership responsibility for the military, whereas the enlisted force corresponds more or less to the blue-collar work force in the civilian sector. Although these characterizations are not absolute (for example, many enlisted personnel have white-collar-type clerical jobs), they nevertheless capture the basic nature of the two forces.

The military personnel system differs from its civilian counterpart in a number of respects. Perhaps the most obvious distinction is that the military maintains an up-through-the-ranks, or closed personnel system, with little or no lateral entry. Thus, management, leadership, and experience are developed solely within the system. As shown in Fig. 1, one important implication of this is that military personnel can, for policy purposes, be categorized into "first-term" and "career" components. That is, first-term and career personnel are likely to be sufficiently different in terms of supply, experience, and skills to warrant being treated as two separate resource categories.

While Fig. 1 provides one way of structuring the defense manpower system, that is, in terms of specific categories of manpower, there are many other potential categorizations. For example, the system might be structured in terms of the occupational mix, the service mix, the mix by function (e.g., strategic versus general-purpose forces), and so forth. The point to be made from Fig. 1 is simply that there are many useful ways of breaking down the defense manpower problem into meaningful pieces. Certain categorizations, such as the military/civilian mix or the officer/enlisted mix, are likely to be important for most policy problems. Others, such as the first-term/career mix or the occupational mix, are likely to be useful for some policy problems but not very important for others.

In a sense, Fig. 1 represents the demand for manpower—specifically, the demand for the different types of manpower used in the defense mission. As such, Fig. 1 is stated in terms of *stocks*—i.e., the numbers and types of personnel. Because of the closed nature of the military personnel system, however, *flows* are equally important. That is, because the military brings all (or almost all) new personnel in at the bottom, the flow of personnel in and through the system and the policies affecting that flow have a great deal to do with how well the military meets the demand, as well as the costs of doing so. In other words, because of the closed nature of the military personnel system (and because the military compensation system is geared to attract only young men and women into the force initially), the military must take in large numbers of inexperienced young people, train them, move them through the system, promote and assign them, etc.

The simplified version of these flows shown in Fig. 2 indicates that the military personnel system has several major components in addition to the demand for manpower. The first is manpower procurement, which has become increasingly important since the removal of the draft. Given present force sizes, the military must attract about 400,000 new recruits each year. After joining, these individuals must be classified according to the assignments they can be used in; they must be trained (basic military training plus whatever specialized skill training they are to receive); and they must be assigned to their first duty station. During the remainder of their initial obligation, these personnel must develop their skills, be promoted as they advance in skill level, and possibly be moved to different assignments. The mili-

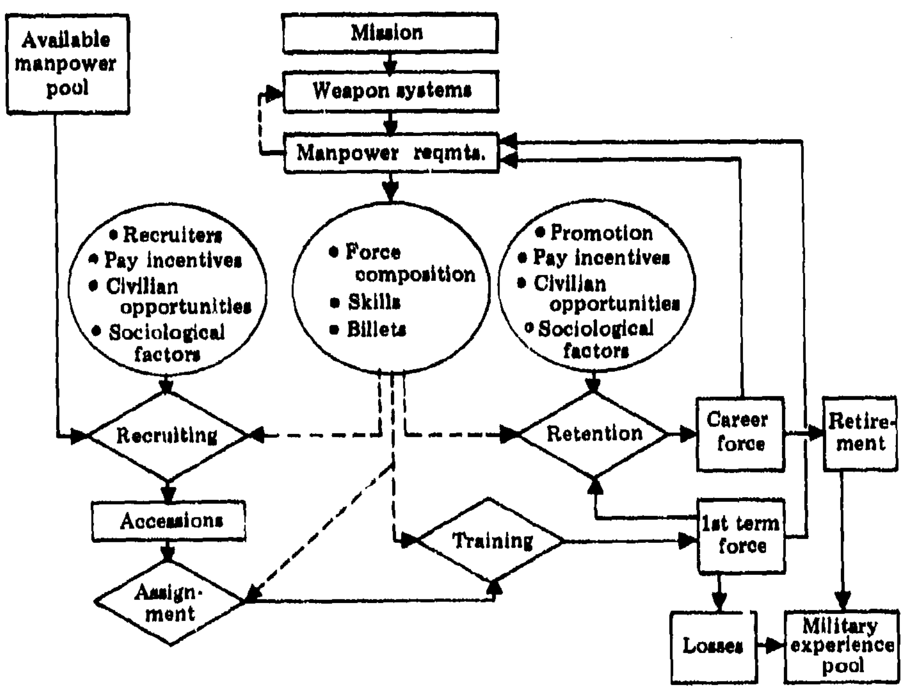

Fig. 2—Military personnel flows

tary wants to retain as career personnel some of those reaching the end of their initial obligation, and for these, the same set of concerns arises once again—i.e., further training, assignment, promotion, etc.

In general, we can describe this entire system as manpower management, where the tools for managing military personnel include initial classification and assignment, training, compensation, promotion, subsequent assignment and rotation, and on-the-job training. All this must be balanced against the military's requirements and the individual's preferences and desires.

However, the defense manpower system is but one aspect of the defense manpower policy problem. To illustrate the complexity of this problem, at one end of the spectrum, defense manpower policy has a major impact on the effectiveness of U.S. military forces. In other words, defense and defense policy shape (and are shaped by) defense manpower and defense manpower policy. Thus, any attempt to deal with the defense manpower policy problem requires a better understanding of how defense manpower and defense manpower policy affect overall defense capabilities and costs.

Second, the nation's economic and social policy can also have an important impact on defense manpower policy, and vice versa. Sociologists and political scientists have long worried about civil/military relations and the factors that affect them. On the one hand, the nation's social values shape the attitudes and behavior of the military in important ways, while on the other, the structure of the military can have significant effects on the role of the military in a democratic society. More specifically, the military can substantially affect the lives and careers of those who have served, including their choice of occupations, their education, and their earnings and employment prospects. To illustrate, the GI Bill has been a significant factor in educating large numbers of former servicemen. (In fact, the military, through the GI Bill, contributes more resources to post-secondary education and training than any other Federal agency.) Similarly, to the extent that military training and experience is valued by civilian employers, military service can be a major source of human-capital formation. Alternatively, depending on the extent of military retirement benefits, military retirees may be discouraged from entering into post-service employment, which indicates that there may be a larger social cost to military retirement than is accounted for in the budget.

In sum, the defense manpower policy problem can be disaggregated into several major components: the defense manpower system, the relationship between defense manpower and defense in general, and the relationship between defense manpower and the nation's economic and social objectives. And the defense manpower system itself can be viewed in terms of its major components: the demand for manpower and the various parts of the military personnel system.

ORGANIZATION OF THE BOOK

Building on the framework outlined above, this book is divided into four parts. The first focuses on the demand for manpower—i.e., manpower requirements—including both the numbers and types of personnel needed and how these requirements are affected by various factors. Not only are manpower requirements important in terms of the defense manpower system, they have an important effect on both defense capabilities and defense costs. The second and third parts of the book focus more specifically on the military personnel system. Because of the special importance attached to the problem of obtaining sufficient numbers and quality of manpower in the absence of a draft, Part II is devoted to military manpower procurement. Part III considers other aspects of the military manpower management problem, including training, promotion, and compensation. Finally, the last part of the book addresses some of the broader economic and social effects associated with defense manpower.

Part I, *Manpower Requirements*, contains four papers dealing both with specific manpower requirements issues and with methodologies for solving manpower requirements problems. The first paper, by Clark, deals with the broadest level of aggregation in the manpower requirements process: the allocation of defense resources between capital and labor. The second paper, by Smoker, deals with the next level of disaggregation in the requirements process—the mix of military and civilian personnel to meet manpower requirements. Smoker not only examines the military/civilian mix but also provides a costing methodology for evaluating potential military/civilian substitutions. Horowitz and Sherman, in the third paper, focus on the effects of personnel characteristics for defense capability and hence on the manpower requirements process in terms of personnel policies. Finally, Jaquette develops an approach for evaluating how manpower requirements should change over time in response to desired changes in force structure and force capabilities.

Part II, *Manpower Procurement*, consists of six papers dealing with recruiting personnel into the military in a volunteer environment. Fechter and Grissmer, in the first two papers, examine the supply of enlisted volunteers for the U.S. military. Withers, in the next paper, examines manpower supply in the United States, Canada, Great Britain, and Australia, offering an international perspective on the determinants of military enlistments. Jehn and Shughart focus on recruiters and recruiting as a tool for attracting enlisted volunteers. In the fifth paper, Martin and Haley discuss a recent DoD experiment in paid radio advertising. This is useful not only because of the role advertising has come to play in the recruiting function but also because it illustrates a methodology—namely, controlled experimentation—for evaluating manpower policies more generally. The last paper, by Lockman, focuses on the use of various enlistment screens to reduce subsequent attrition in the enlisted forces.

Part III, *Personnel Management*, also contains six papers, but these deal with various aspects of military personnel management. In the first paper, Gay and Albrecht examine the determinants of performance of enlisted personnel on the job, including experience, training, and personal characteristics. Vineberg and Taylor, in the second paper, discuss ways of measuring performance on the job, given the importance of performance measures for subsequent force management. Alley discusses the results of a study dealing with the management of the Air Force ROTC program. Two papers dealing with retention are included: Grace discusses factors affecting retention in the enlisted forces, and O'Connell discusses the retention and performance of Air Force Academy graduates and the factors affecting these. Finally, Munch provides a methodology for managing the Services' bonuses programs, perhaps the most important tool for encouraging retention of enlisted personnel.

Part IV, *Manpower and Social Policy*, contains three papers dealing with various aspects of the relationship between the military and civil sectors. Thomas examines some of the trends in the utilization of women by the Navy, in the context of social trends. Although the utilization of women is an important issue for personnel management, their increased use in the military has been driven by a number of external as well as internal factors. Knapp, in the second paper, takes a somewhat different perspective on the relationship between military service and social policy by examining the effects of military training and experience on individuals' post-service earnings. O'Neill et al. discuss the utilization of the GI Bill by former servicemen, in order to shed some light on what must be regarded as one of the most important links between the military and civil sectors during the postwar period.

The 19 papers presented here thus offer a useful first step in structuring the defense manpower policy problem. There are obviously large gaps, but it is hoped that these papers will provide a good beginning.

Part I

MANPOWER REQUIREMENTS

CAPITAL-LABOR RATIOS IN A MILITARY SERVICE: A PUTTY-CLAY APPLICATION

Cdr. Rolf Clark[1]
Operations Study Group, U.S. Navy

Conflicting viewpoints are presented regarding rising labor costs and their proper impact on weapon acquisitions: Some claim that systems should become more capital-intensive, others claim the opposite. The conflict may result from differing viewpoints of defense capital and its valuation, rather than from any basic inconsistency. Those favoring increased capital-intensity may be considering aggregate defense systems, while those with the opposite advice may be considering only new, or incremental, systems.

With changes in capital/labor ratios (K/L) attributed to changes in wage/rental ratios, empirical results for the Navy show that substitution elasticity is less than or greater than unity depending on whether K/L represents total (aggregate) systems or incremental systems. The conflicting viewpoints are then synthesized within an "ex ante substitution/ex post fixivity" (putty/clay) model of system accumulation.

Theoretical issues considered include capital valuation, factor pricing, defense output nonmeasurability, and embodiment of technical change.

INTRODUCTION

An important policy question is whether or not defense systems should become less labor-intensive than present trends indicate. The popular answer seems to be that they should. This conclusion is founded on seemingly obvious reasoning: The rising cost of manpower rela-

[1] The author is no longer with the Operations Study Group; he is presently at the Brookings Institution.

tive to the cost of hardware has not been matched by a comparable shift away from systems using the expensive manpower input. A Brookings publication demonstrated the view quite forcibly:

> The point here is . . . to emphasize that at the very time the price of military manpower is rising sharply, it is being used more, rather than less, intensively. Thus the change in the use of defense manpower has reinforced, rather than partly offset, the effect of higher pay on the defense budget.[8]

The validity of such conclusions will be partially explored here. The converse viewpoint—that systems may be becoming too capital-intensive (and therefore presumably too complex and sophisticated for the military labor force)—will also be aired. This view, which is more widely heard among operators than analysts, will find some support in the empirical data to be presented. After some discussion of the economic constraints involved, the conclusion is offered that the call for greater automation and capital intensity may at least be premature. In fact, within the flexibility allowed, system acquisitions may have become more capital-intensive than the relative price changes in the hardware and manpower inputs warrant. This conjecture will be supported by empirical evidence on U.S. Navy systems analyzed during the 1955-1973 period. These results therefore apply directly only to the Navy, though some considerations will obviously be common to all services.

The divergent viewpoints on the proper course for future system configurations can be synthesized. Those arguing for greater capital intensity are probably including the *cumulative total* of all defense procurements in their analysis. Those arguing against increasing capital intensity are probably internalizing only the new or *incremental* systems.

These matters can be rationally discussed only after some orientation in the models assumed. This requires exploring at least the following issues: the use of aggregate input factors; the measurement of "capital" and "labor" in defense; the pricing of capital and labor; the nonavailability of output measures for defense; the elasticity of substitution between capital and labor; and the "ex-ante substitution/ex-post fixivity" (or putty-clay) character of defense systems.

Aggregation of Factors

Many will react with disdain toward any discussion that treats capital, or even labor, in aggregate terms. Indeed, treating capital as

[8] See E. R. Fried et al., *Setting National Priorities, The 1974 Budget,* The Brookings Institution, Washington, D.C., p. 300.

some form of homogeneous mass is a severe oversimplification. The same may be true for labor aggregation. Yet the concept of aggregation has its uses if not pushed too far. When budgets are limited, the decision to allocate funds to "manpower" budgets (such as recruiting or training) or to "hardware" budgets (such as procurement) is difficult enough. The capital versus labor aggregation translates somewhat usefully into hardware versus manpower planning.

Disaggregation of capital and labor into specific categories is common in the many quantitative techniques of operations research, such as linear and dynamic programming or input-output analysis. But although these techniques are easily applied to short-range problems, they are less useful for long-range planning. The complexity in terms of numbers of variables becomes prohibitive if long time frames are combined with multiple variables within each single time frame. The short-term solutions and what they suggest period-to-period are useful but should be complemented with the long-range economic perspectives that are more conveniently described in aggregate terms.

In a direct sense, whether automation or manualization should be stressed in future systems is a realistic question for planners. Studies of the nation's labor force and, consequently, of the skill potential of the average military recruit are available. Decisions on deliberate efforts to simplify or not to simplify systems in general can be made. Toward that end, knowledge of past trends on capital-labor ratios in aggregate terms is useful. Aggregate capital and labor factors are in fact used by both critics and supporters of defense management. Therefore it is worthwhile to explore the validity of their use.

Capital as a Volume Measure

If capital-labor ratios are to be compared with their relative price ratios, then measures for the two inputs must be consistent with measures for the prices. The labor factor presents no obvious problem; the labor input for defense can be taken as the manpower hired and the price of labor as the mean wage. Wages are then the rental cost of manpower, at least in a crude sense. But the amount of capital used for defense and the commensurate price for that capital is a different matter. A complete discussion of the problems with capital measurement and pricing would soon lead us to the controversies in capital theory that are still raging among leading theoretical economists.[a] Here we will have to be content with a broad-brush statement of the problem as applied to defense.

[a] For a more detailed but still brief discussion of the controversies, see the introduction to G. C. Harcourt and N. F. Liang, *Capital and Growth*, Penguin Books, Baltimore, 1971.

There are two basic ways to measure capital. Most economists favor the "value" measure, which values capital at the discounted present value of its future earnings. Accountants prefer to use the "volume" measure of capital, wherein capital is measured as the sum total of acquisitions, adjusted for depreciation. If this amount is adjusted also for changes in price levels, then the volume of capital can be measured as the replacement cost of the existing physical stock of (depreciated) capital goods. This volume measure provides a proxy for the "real" measure of capital.

Sir John Hicks refers to the value measure of capital as "forward-looking" capital and the volume measure as "backward-looking."[4] This presentation uses the backward-looking measure, not by choice so much as by default. The forward-looking measure requires knowing future outputs. Yet in defense there *is* no realistically measurable output—at least not in aggregate terms. The value measure therefore abandons us.

Any aggregate measure of defense capital must be in the form of a physical stock of capital assets. Asset values purged of the effects of inflation and depreciation are indirectly available, as we shall see in a later empirical section. Estimating such asset value is a formidable *counting* task but presents no major *theoretical* difficulties. What requires some care, however, is estimating the cost of holding such physical stock.

The Cost of Capital

The most obvious and popular measure of capital cost is the real rate of interest on risk-free money instruments such as government bonds. Properly adjusted for depreciation, an argument can be made for pricing capital rental in this way. But that argument hinges on the subtle and implicit assumption that capital value and capital volume measures coincide—that what has been paid for assets is (with depreciation and inflation abstracted) equal to the present value of what the assets will produce.

There are at least two major reasons why these backward- and forward-looking measures may not coincide. The first is that defense assets probably do not come under the rubric of perfect competition, which would assure that capital value and capital volume coincided.[5] Without perfect competition, it would only be by chance that what was paid for an asset equals what it is worth in productive terms.

[4] John Hicks, *Capital and Time*, Oxford, London, 1973, p. 157.

[5] Perfect malleability of capital would also be required so that changes in defense needs could be accommodated by changing the configuration of existing capital.

The second reason that capital volume and capital value may not coincide is even more fundamental and requires understanding that interest rates, such as those on government bonds, are essentially the opportunity costs of funds on the open market. Specifically, an "open market" includes the assumption that there is no constraint on the amount of funds that can be borrowed or loaned by the agents in the market. Yet the Department of Defense (DoD) is certainly constrained in its budget flexibility. In fact, it cannot even utilize the money markets to borrow or lend to change its annual budget. The DoD, therefore, operates under a rigid form of budget constraint. Opportunity costs under unconstrained and under constrained conditions are almost completely unrelated; therefore, using a market interest rate to measure the value of capital to the DoD has no theoretical basis.

There is, of course, adequate ground for claiming that the risk-free interest rate is the cost *to society* of allocating funds to defense. But our aim is to evaluate the effectiveness of defense planners in their management task within the constraints society has imposed. One of those constraints is rigid budgetary control; and the opportunity cost of capital, if used, must reflect this constraint. That, however, is precisely where the major problem with opportunity costs arises. It is well known that opportunity costs are the marginal products of increments in the constrained factor.[6] In this case, that means the additional defense product resulting from an increment in the budget allotment. Since defense output defies measurement, so does the concept of marginal product of that output. Opportunity costs—specifically, interest rates—thus lead nowhere as measures of the cost of capital to defense.

Then what is available as a price for defense capital? A price for aggregate capital is needed, and capital, unlike labor, does not come in consistent units.[7] This is where the interest rate would be so convenient in that it reflects the annual rental of a "dollar" of capital. Aggregate capital stock is defined here to be made up of arbitrary units of "machines." But how does one obtain the price of a "machine?" The answer is, One doesn't—and, fortunately, one needn't.

Our intent is to compare capital-labor ratios with their associated cost ratios. What are the relative movements of these ratios over time? For example, did the capital-labor ratio double during the same time that the ratio of the cost of labor to the cost of capital doubled? Such considerations do not require knowing if the original ratio was

[6] As perhaps best demonstrated by the dual variables of mathematical programs. In the multiperiod investment scenario, this matter was first, and perhaps best, illustrated in Martin Weingartner, *Mathematical Programming and the Analysis of Capital Budgeting Problems*, Markham, Chicago, 1967.

[7] There is good ground for claiming that although labor can be counted in units of persons, people differ in their productive capacity as much as, if not more than, "machines." This matter is not under dicussion here, however.

efficient; they only require knowing the proportional changes in the two time series.

It is claimed here that the ratio of appropriate price indices for labor to that for (durable) goods provides a theoretically consistent measure for the ratio of the cost of labor to the cost of capital. This ratio is consistent with the ratio of capital to labor, since both the capital and labor measures are backward-looking (capital being the depreciated assets bought and labor the man-years hired) and the price indices are also backward-looking (being based on what actually was paid for each).

Exactly what indices are used in the empirical application to the U.S. Navy is discussed in a later section. For the present, it is sufficient to state that they are derived from indices compared in the *Survey of Current Business* for hardware and from DoD sources for labor. The index for Federal Purchases of Goods and Services was specifically not used because it did not seem to reflect defense purchases of hardware.

Some caveats must be stated. First, when capital "purchased" is combined with labor "hired," it would be better to have the rental index of hardware rather than its purchase index be consistent with the labor measurement. To use the index series available, it must be assumed that the purchase price of hardware and what its rental price *would* be are linearly dependent. This theoretical assumption is not considered too heroic.

Second, the available price indices may not reflect changes in defense factor costs. They probably do not in the short run, although they may well do so in the long run we shall be considering. At any rate, for the present there are no realistic alternative indices.[8]

Since defense has no measurable output, defense capital, by default, must take the form of capital stocks, measured in terms of the constant dollar replacement cost of defense assets. If some arbitrary input amount in constant dollars—say $100—is defined to be "a machine," then capital assets can be enumerated in terms of the number of machines in the defense arsenal each year. Depreciation will have been accounted for and so will inflation. Capital then is in units parallel to labor, which is measured in units of "men." In essence, capital-labor ratios translate directly into machine-men ratios.

Both capital and labor being in terms of accumulated stocks, the selected prices must also be in backward-looking terms. Although the price of capital, i.e., machines, is not independently available, time

[8] The Commerce Department's Bureau of Economic Analysis is currently engaged in a major effort to include specific defense indices in the *Survey of Current Business*. Such indices should be available soon. Meanwhile, proxies based on related commercial indices (e.g., wholesale machinery and equipment, electronics) seem the best alternative and have been used here.

series on price indices for durable equipments are. The required ratios of cost of labor to cost of capital are estimated directly from the labor and equipment series. Since *proportional changes* in these ratios over time (rather than the values of the ratios at specific times) are the needed series, theoretial consistency is achieved.

DEFENSE ACQUISITIONS AND PUTTY-CLAY ACCUMULATION

The central point of this presentation is that in analyzing defense capital-labor ratios and their changes over time, it makes a huge difference whether one uses the total *accumulated* stocks of capital and labor or whether one uses only the *incremental* capital and labor changes under the control of defense managers. As an obviously oversimplified example, if the ratio of cost of labor to cost of capital increased 10 percent last year, should the capital-labor ratio of the total accumulation of defense assets and manpower also increase by 10 percent, or should only the capital-labor ratios of last year's acquisitions increase by 10 percent? Placed in these terms (and acknowledging some implicit assumptions regarding substitution elasticity), it seems obvious that the incremental acquisitions are the pertinent ones. We can hardly blame present managers for systems accumulated 10 years ago but still in operation.

Defense systems are not, once procured, malleable. They cannot be reconfigured to use less labor just because the cost of labor has risen more than the cost of capital. Granted, some modifications are possible, but ships cannot be transformed into helicopters, or adding machines into computers. The change must be evolutionary, and the evolution is limited by the procurement budget and by the retirement rate of the old equipment.

We have, in other words, a classic example of "ex-ante substitution/ex-post fixivity," or, in simpler terms, "putty-clay" growth of systems. In the planning phases, there is flexibility in the relative amounts of capital and labor to be used in a new system. But once procurement begins, the capital-labor ratio associated with any system, and with all existing systems, is fixed.

Any analysis of capital-labor ratios relative to price ratios should account for this putty-clay aspect of the problem. This presentation will compare results obtained under the putty-clay assumptions and under the "putty-putty" assumptions, which seem to be more commonly implicit in analyses of this type. The analysis will hinge on comparing the imputed elasticity of substitution under the two approaches.

Substitution Elasticity as a Collective Parameter for Explaining Changes in Capital-Labor Ratios

Comparing capital-labor input ratios with price ratios of the cost of labor to the cost of capital involves some knowledge of the substitutability between the input factors. If *fixed* factor production dominates, then the capital-labor ratio is fixed and changes in the relative factor prices will have no effect on the factor ratios. Conversely, if some substitution possibilities exist, then response of capital-labor ratios to the cost ratios can be expected. It seems obvious that defense system acquisition does have some flexibility in factor utilization—for example, ships' boilers can be manually controlled or controlled by computer.

The obvious economic parameter for estimating such flexibility is Hicks' elasticity of substitution. Indeed, such estimation will be used in the results presented here. However, using substitution elasticity as the parameter accounting for all the capital-labor ratio reflex to price changes requires several implicit assumptions. One of the more obvious is that economics (rather than politics, say) dominates the system acquisition process; at least, it dominates the process as far as capital-labor utilization is concerned.

One other implicit assumption is that factor substitution, rather than technical progress, is the cause of changes in the factor ratios. It could be argued, for example, that technical progress has been such that defense systems *required* the use of more capital and less labor, and that prices in these two inputs just happened to change during the same period. However, it can be shown that attempts to ascribe factor changes to technical progress instead of to substitution elasticity are largely semantic exercises.[9] For practical purposes, the data available support only a one-parameter estimate, and here we shall be content with the elasticity of substitution.

THE DATA AND THE EMPIRICAL RESULTS

The substitution elasticity can be derived using total accumulated capital and labor inputs or using the incremental inputs. The two estimates can then be compared with the purpose of explaining the divergence of viewpoints between those who proffer greater capital intensity and those who opt for less.

[9] A discussion of the technical progress and substitution elasticity in the defense context is contained in R. H. Clark, *Capital/Labor Substitution and Factor Price Ratios in a Military Service: A Study of Defense Resource Allocation*, Ph.D. dissertation, University of Massachusetts, Amherst, 1975.

The Data

Table 1 shows trends from 1956 to 1974 for capital assets in deflated replacement value and manpower levels in full utilization terms. These series, as well as those to be presented in the subsequent tables and figure, are derived in detail in the table's source. It suffices here to mention that the capital, or hardware, series accounts for inflation, age of equipment, depreciation, and weighting by type of equipment. Research and development expenditures are, however, abstracted from the series. The manpower series reflects adjustment for *required*,

Table 1

ADJUSTED TOTAL CAPITAL (HARDWARE) AND LABOR (MANPOWER) LEVELS FOR THE U.S. NAVY, EXCLUSIVE OF MARINE CORPS, END OF FISCAL YEAR
(Capital in billions of 1967 dollars, labor in millions of persons)

Fiscal Year	Capital (hardware)	Labor (manpower)	Capital/Labor Ratio (K/L)
1955	44.4	.98	45.2
1956	43.3	.96	44.9
1957	40.7	.96	42.3
1958	38.8	.98	39.8
1959	38.0	.95	39.8
1960	42.1	.94	44.9
1961	44.3	.94	47.3
1962	49.3	.98	50.5
1963	52.3	.97	53.9
1964	54.7	.99	55.2
1965	55.7	.98	56.9
1966	58.1	1.07	54.4
1967	61.7	1.11	55.5
1968	63.3	1.09	58.3
1969	61.5	1.08	57.1
1970	58.2	.97	60.2
1971	56.4	.89	63.6
1972	53.7	.85	63.0
1973	52.6	.84	62.7
1974	51.1	.82	62.0

SOURCE: R. H. Clark, *Capital/Labor Substitution and Factor Ratios in a Military Service: A Study of Defense Resource Allocation*, Ph.D. dissertation, University of Massachusetts, Amherst, 1975, Tables 13 and 27.

rather than *on-board,* manpower levels. Marine Corps capital and labor have been extracted from the data.

The purpose is to compare the series of capital-labor ratios, K/L, with the corresponding ratio of cost of labor to cost of capital, w/r. This latter series is presented in Table 2, where the cost-of-capital index is derived from various combinations of wholesale price indices contained in the *Survey of Current Business.* Different equipments are weighted for the type of input most appropriate; for example, Navy ships would be most heavily weighted by the Machinery and Equipment index, whereas supply inventories are based more heavily on the Durable Goods index. The composite cost-of-capital index is then weighted by equipment type. Thus, if ships are valued at $15 billion in year x and supplies at $5 billion, the composite index would reflect

Table 2

ADJUSTED PRICE INDICES FOR DEFENSE CAPITAL AND LABOR, U.S. NAVY, END OF FISCAL YEAR (1967 = 100)

Fiscal Year	Cost-of-Capital Index (r)	Cost-of-Labor Index (w)	w/r
1955	79.3	71.8	.89
1956	85.0	74.2	.84
1957	89.4	74.3	.83
1958	90.8	75.6	.83
1959	92.6	79.5	.86
1960	92.8	79.5	.86
1961	92.5	81.3	.88
1962	92.5	81.3	.88
1963	92.7	82.1	.89
1964	93.5	87.6	.94
1965	94.6	91.3	.96
1966	97.2	96.1	.99
1967	100.0	100.0	1.00
1968	103.3	103.8	1.00
1969	107.0	110.2	1.03
1970	111.7	123.6	1.11
1971	116.0	131.4	1.13
1972	119.1	148.6	1.25
1973	124.1	165.8	1.34
1974	142.1	192.0	1.36

SOURCE: R. H. Clark, *Capital/Labor Substitution and Factor Price Ratios in a Military Service. A Study of Defense Resource Allocation,* Ph.D. dissertation, University of Massachusetts, Amherst, 1975, Table 9.

the ship price factor at three times the weight of the supply price factor. The cost-of-labor index is derived from DoD sources and includes adjustments for military compensation. This index has been adjusted to include civilian labor costs. Again, the details resulting in the series are contained in the table's source.

The w/r series represents the annual w/r ratio relative to the 1967 base year. Absolute values of w/r are not available, since (as was dicussed earlier) there is no actual unit of hardware to which we can assign a price.

Having w/r and the cumulative K/L series, it remains to present the incremental capital-labor series, which is denoted k/m (m for manpower). Table 3 contains this series. The k/m series is derived primarily from information on annual procurement budgets. However, assumptions regarding procurement, depreciation, and maintenance are implicit in the series. Briefly, these assumptions are (1) the annual

Table 3

CAPITAL-LABOR RATIO INPUT TO NEW SYSTEMS DELIVERED IN SELECTED FISCAL YEARS

Fiscal Year	$(k/m)_t$	Fiscal Year	$(k/m)_t$
1955	—	1965	74.04
1956	41.55	1966	29.30
1957	16.71	1967	65.17
1958	22.19	1968	81.21
1959	40.48	1969	48.22
1960	94.31	1970	84.59
1961	66.63	1971	92.31
1962	76.01	1972	57.89
1963	76.23	1973	59.88
1964	65.53	1974	55.29

procurement budget, adjusted to constant dollars, represents new (incremental) capital; (2) annual maintenance funds are adequate and totally spent for keeping those assets retained to the next period in their original working order; (3) those assets not retained have, on the average, the same intrinsic capital-labor ratio as the overall assets at the beginning of the time period under consideration. Under these assumptions, the capital-labor ratio of incremental equipments $(k/m)_t$ can be shown to derive from the following formula:[10]

[10] Ibid., p. 130.

$$(k/m)_{t-1} = \frac{(K/L)_t K_t - (K/L)_{t-1} K_t^*}{k_{t-1}^*}$$

where K^*_t is assets carried forward from t−1 to t,
$(K/L)_t$ is the cumulative capital-labor ratio at time t, and
k^*_{t-1} is new equipment arriving during the period t−1 to t.

The Results

The two series K/L and k/m can be used to obtain separate estimates for substitution elasticity λ. Either

$$(K/L)_t = A(w/r)_t\lambda$$

or

$$(k/m)_t = B(w/r)_t\lambda$$

may be used where A and B are constants of integration equaling the base-year values for K/L and k/m.

Table 4 presents estimates for λ under the two models and for two different time periods. The logically preferred time frame is 1956 to 1972, since it represents an approximate cycle from the end of one war (Korea) to the end of another (Vietnam). If it is agreed that decisionmakers should be judged on their actions within the flexibility allowed, then the putty-clay model provides a best estimate of 1.74 for substitution elasticity. Economywide, I tend to believe in an estimate of about unity for this parameter, so the evidence does not support a

Table 4

RESULTS OF REGRESSING FORMS OF HARDWARE MANPOWER RATIOS ON FACTOR PRICE RATIOS FOR ALTERNATIVE TIME PERIODS

	$K/L = A(w/r)^{\lambda}$		$k/m = B(w/r)^{\lambda}$	
Model	1955-1974	1956-1972	1955-1974	1956-1972
MLE for λ	0.855	1.13	0.952	1.74
90% confidence interval for λ	(0.64 to 1.07)	(0.86 to 1.40)	(−0.27 to 2.17)	(−0.02 to 3.50)
Coefficient of determination R^2	0.722	.775	0.098	0.167

SOURCE: R. H. Clark, *Capital/Labor Substitution and Factor Price Ratios in a Military Service: A Study of Defense Resource Allocation*, Ph.D. dissertation, University of Massachusetts, Amherst, 1975, Chap. 4.

conclusion that planners have failed to respond to changes in the factor price ratio.

Even if the cumulative model is assumed (putty-putty), the estimate for λ is 1.13, still greater than unity.

Stating absolute values for defense goods and whether they are "high enough" or "too high" is speculation. What is not speculation is what the original intent of this paper proposed. Namely, the incremental putty-clay model (k/m) provides a much higher "best" estimate for λ than does the cumulative model (K/L). Analysts implicitly considering new or incremental defense systems would conclude that planners had responded to the rising ratio of cost of labor to cost of capital by shifting rather strongly toward capital-intensive systems. Those implicitly including all cumulative defense assets in their analysis would conclude that planners had shifted much less strongly toward capital intensity. The data tend to support this synthesis.

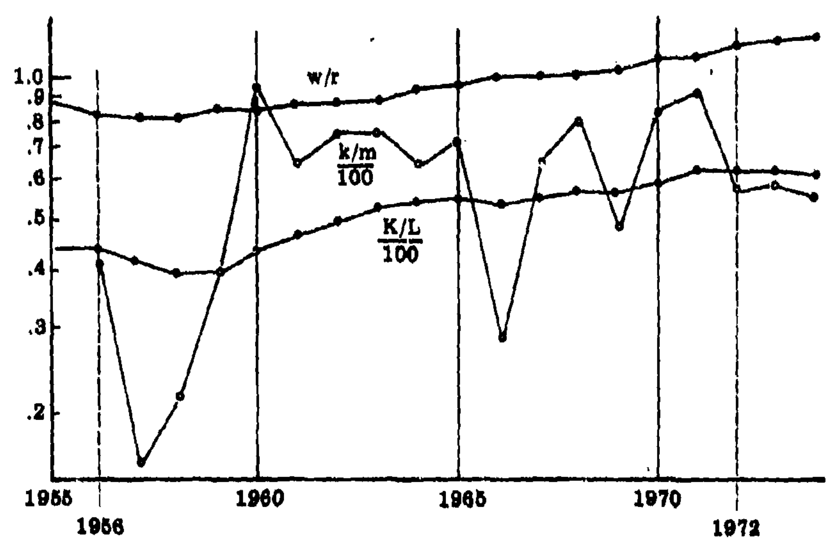

Fig. 1—Derived relationship between (k/m), (K/L), and (w/r) for 1955-1974

COST AS A CRITERION IN DETERMINING THE MIX OF MILITARY AND CIVILIAN PERSONNEL

Capt. Roy E. Smoker
United States Air Force

Historically, comparisons of military and civilian costs have not entered the manpower requirements process. Rather, DoD policy has required civilian personnel to fill all manpower positions not requiring military incumbency by reason of law, training security, rotation, combat readiness, or need for military background. This policy was revised by the Congress in Public Law 93-365, which states: "It is the sense of Congress that the DoD shall use the least costly form of manpower that is consistent with military requirements . . . ."

In examining the impact of this policy change on the military/civilian mix, a consistent costing methodology must be applied to military and civilian resources that perform similar functions. Costs peculiar to the military occupational specialty or a civilian job series must be evaluated under both the closed military and open civilian personnel systems. A cost quantification project identifying the key methodological issues and their resolution is described and results are presented.

INTRODUCTION

Historically, comparison of military and civilian costs has not entered the manpower requirements process. Rather, Department of Defense (DoD) policy has been to place civilian personnel in all manpower positions not requiring military incumbency. The 93rd Congress revised this policy in Public Law 93-365: "It is the sense of Congress that the DoD shall use the least costly form of manpower that is consistent with military requirements."

More recently, in the 94th Congress, the Committee on Armed

Services reported favorably on H.R. 6674, the Defense Appropriations Bill:

> For the past decade, the United States has been moving toward a higher priced defense structure. One of the most contributing factors has been the marked increase in the cost of defense manpower; indeed manpower costs absorb over half of the total defense budget, a situation brought on by increases in the price of personnel by more intensive use of manpower.
>
> A sizable part of the cost of manpower is determined by policy issues that are related to efficiency rather than foreign policy or defense strategy. The fact that these policies were developed when military manpower, under conscription, was plentiful and relatively cheap underscores the need for reassessment.
>
> Thus far, principal attention has been directed toward questions of efficiency on the margin that have yielded only modest returns. Major changes in the efficiency with which the Defense Department operates calls for more far-reaching studies of the underlying philosophy of manpower utilization.

This paper examines the philosophy of manpower use in terms of the mix of military and civilian personnel, first when cost is not a criterion and, second, when cost enters the determination process.

Traditionally, comparisons of uniformed military and civilian manpower have not been made for two reasons: First, for certain missions involving combat or mobilization and deployment as well as training, military manpower was considered more valuable than civilian manpower; second, it would have been unacceptable to society to use less costly conscripted military personnel where civilian personnel could perform a service of equal value.

In the all-volunteer environment of today, the policies of conscription no longer apply. With Congress leading the way on pay comparability of military and civilian personnel, the idea of equal pay for equal work has developed prominence. Yet the return per dollar spent on military manpower continues to be perceived as greater than would be the return per dollar spent on civilian manpower under combat, combat training, or other military circumstances. If voluntary military personnel can perform support missions equally as well as civilian personnel, and if the military manpower cost is less than that of civilian manpower, then military personnel should perform those missions. It is necessary first to determine in what instances military manpower is perceived to be of greater value than civilian manpower. Second, it is necessary to determine in what instances military manpower could perform equally well on workloads currently performed by civilian manpower. Then it must be determined whether military or civilian manpower is the least costly resource in performing a given workload.

TRADITIONAL MILITARY WORKLOADS

One method of determining where the use of military manpower for defense missions is perceived to yield a greater benefit than would the use of civilian manpower is to examine those workloads traditionally performed by the military. A partial list includes:

1. Combat workloads performed by combat aircrews, perimeter defense sentries, surface-ship and submarine crews, tank crews, etc.
2. Direct combat support and mobility workloads performed by field maintenance crews, munitions loaders, intelligence collectors, etc.
3. Training workloads required to maintain the high degree of proficiency necessary to respond in timely fashion to the challenges of combat, direct combat support, and mobility.

Although these and other workloads are generally perceived to be military, there are instances where in-house and contract civilian manpower have performed workloads of a military nature. The Bird Air airlift of cargo into Phnom Penh during early 1975 is a recent example of military workloads being contracted. The use of logistics rapid aircraft maintenance and field teams during the Vietnam conflict is an example of in-house civilian personnel performing a direct combat support role.

To determine the instances in which military personnel could equally well perform workloads currently performed by civilians, a look at recent civilianization actions directed by the DoD is helpful. Since FY 1964, the Office of the Secretary of Defense (OSD) has imposed a number of civilian substitution programs on the services. During the period from FY 1972 through FY 1975, the Air Force was required to convert 17,000 military positions to civilian. Presumably, in these conversion actions, the same workload was performed by military personnel before and civilian personnel after the conversion.

A primary reason for the civilian substitution program was the potential for dollar savings. These dollar savings would accrue not because civilian manpower was less costly on a one-for-one trade with military manpower, but because military manpower positions require additional manpower positions to be budgeted for training, transients, personnel support, medical treatment, welfare, and recreation. The substitution of one civilian position for one military position would allow for the elimination of a small portion of another military position, thereby creating a net manpower and financial savings.

Because of DoD policy that "civilians shall be used in all positions which do not require military incumbents for reason of law, training, security, discipline, rotation, or combat readiness, or which do not require a military background for successful performance of the duties involved," relative cost was not a criterion for determining which positions to civilianize. As a result, no consistent method was applied to compare the cost of military and civilian manpower resources capable of performing equivalent occupational missions during the period of civilian substitution programs.

METHOD

Since the cost elements to be defined are to be used to determine the mix of military and civilian manpower requirements, it is assumed that a certain workload generates a certain requirement for manpower. Under this assumption and the implied assumption of civilianization that military and civilian manpower can perform a specified workload equally well, the services would not achieve the maximum output per dollar spent if they were to employ civilian (military) manpower where military (civilian) manpower proved to be less costly. Figure 1 indicates this more clearly.

The curves V_1, V_2, V_3, etc., represent various levels of contribution to defense missions. These curves exhibit three specific characteristics: (1) they never intersect each other; (2) they are convex to the origin; and (3) curves further from the origin represent greater levels of contribution to defense missions. The abscissa represents the amount of military resources corresponding to any point in the diagram. The budget constraint lines show both the level of budgeted dollars dedicated to a given defense mission and the relative costs of the two resources that may be used.

Figure 1 depicts the case that would be expected to occur as military pay becomes comparable to civilian pay near the beginning of the all-volunteer era. Budget line AB has a negative slope less than unity, indicating that under conscription the cost of military manpower is less than the cost of civilian manpower. With the AB budget, C_1 of civilian and M_1 of military manpower are used; and V_3 is the level of contribution to defense missions where budget line AB is tangent to V_3 at point T_3. Along budget line AD, however, the cost of military manpower has increased to equality with civilian manpower cost. The slope of budget line AD, therefore, is exactly negative one. The highest level of contribution to defense missions along AD is V_1, represented by tangency at T_1.

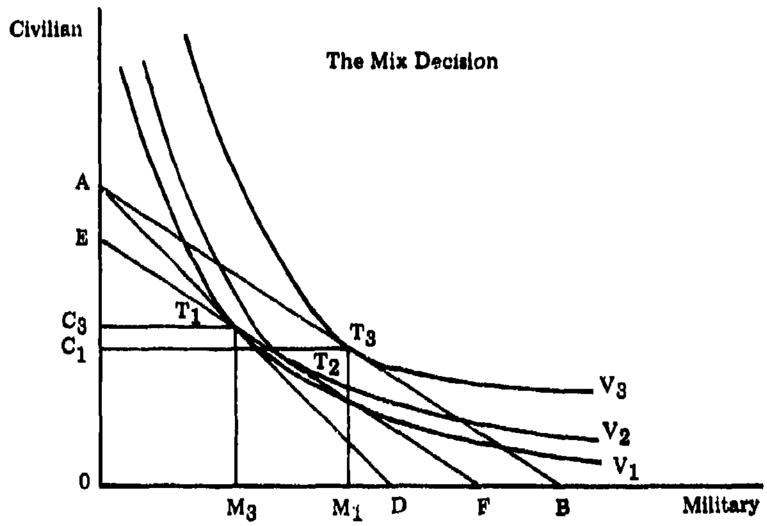

Fig. 1—The mix decision

Figure 2 depicts the case that would be expected when civilian substitution programs are imposed on the services without consideration of relative costs. Assuming that military support space requirements are zero[1] and that the numbers of civilian and military manpower positions before substitution are represented by C_1 and M_1, then one-for-one military to civilian substitution would take place along line AD. Note that line AD is not necessarily a budget line. In fact, line AD can be considered to be a budget line only if the cost for military and civilian manpower is equal for all possible workload requirements to be performed by both types of resources.

As shown in Fig. 2a, a movement from M_1 in the direction of M_3 along the substitution line AD provides a budget saving only if the cost of civilian manpower is less than that of military manpower along some budget line EF. The budget saving being reflected by the parallel budget line GH is tangent to V_1 at T_1. Alternatively, if the cost of civilian manpower is greater than that of military manpower along

[1] Non-zero military support space requirements would increase the slope of line AD, affecting only the rate of substitution of civilian personnel for military, not the conclusions of the analysis.

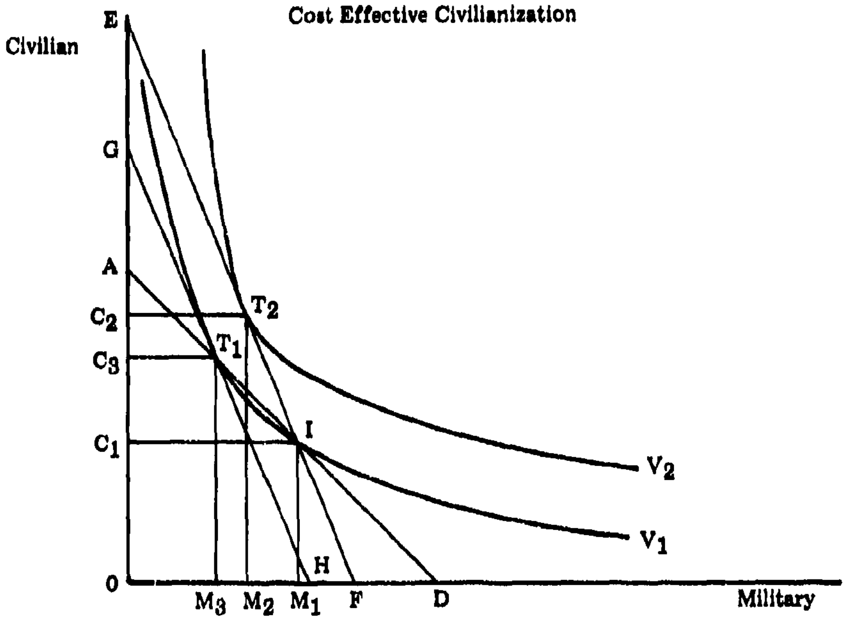

Fig. 2a—Cost-effective civilianization

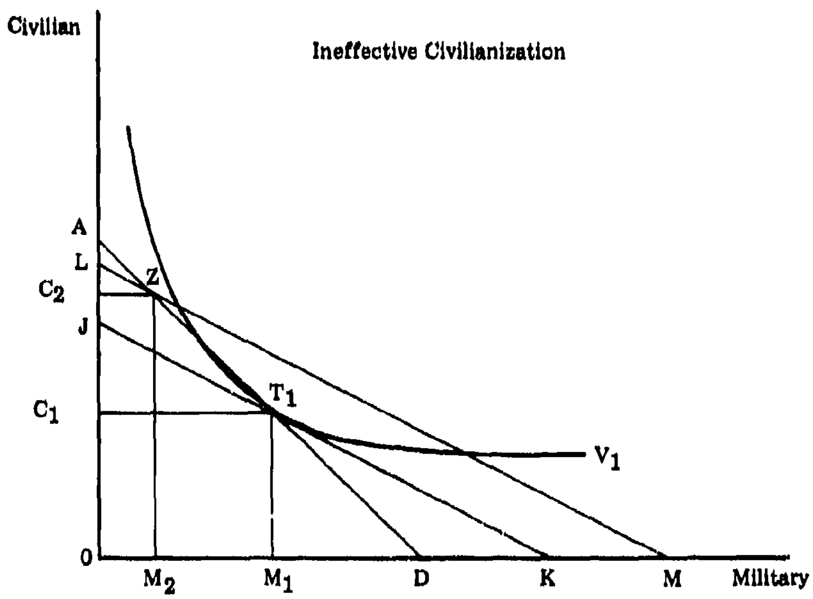

Fig. 2b—Ineffective civilianization

some budget line JK, as in Fig. 2b, a movement from M_1 in the direction of M_2 along the substitution line AD requires an increase in the budget level from JK to LM, with the possibility that the increased budget would provide a reduced contribution to the defense mission, as at Z in Fig. 2b.

Four important observations may be made from Fig. 2. First, military manpower may be converted to civilian along a given budget line EF (in Fig. 2a) if the tangency at T has not already been achieved. This conversion from (C_1, M_1) to (C_2, M_2) enhances the contribution to defense missions but does not yield a budget saving. Second, substitution actions may take place along AD, moving from I to T_1, achieving a budget saving without reducing the level of contribution to defense missions as long as the slope of the substitution line AD is less than the slope of the budget line EF. Third, conversion of military manpower to civilian along a budget line such as JK in Fig. 2b would be a movement away from the tangency point at T_1 where the highest level of contribution to defense missions achievable with budget JK is reached. Fourth, civilianization along substitution line AD in Fig. 2b does not provide for the use of the least costly resource consistent with defense requirements as long as the slope of AD exceeds the slope of budget line JK.

It is now possibie to formulate hypotheses about the results of a program that did not include comparative costs as guidelines for determining which positions to convert. The first hypothesis is that an optimum mix did not exist before civilian substitution.

The second hypothesis is that the civilian substitution program did not achieve an optimum mix of military and civilian resources. The term optimum is defined here to imply minimization of cost subject to a given output.

COST QUANTIFICATION

Once the relevancy of costs to the question of the mix of civilian and military manpower is understood, the next step is to specify those cost elements that should be included in a comparative analysis. The current criteria identify specific occupations that involve risk, dislocation, family separation, and other factors for which the opportunity cost is difficult to quantify. Yet it should be recognized that given the ability to measure these specific costs, the services will be willing to pay them only for the employment of military personnel unless prior contractual agreements can be used to retain civilian personnel willing to subject themselves to the potential hazards, mobility, and disciplinary rigors of military life.

Table 1 presents a representative list of occupations where military and civilian personnel could perform equivalent functions during peacetime operations. The cost elements applicable to military and civilian personnel performing these functions are specified in Table 2. Under each of these elements, cost is defined as the identifiable average annual incumbency cost attributable to the federal government during a specified period of time. As each of the cost elements is defined independently of the others, additivity across cost elements by grade of manpower resource will be assumed. This assumption is particularly necessary where specific cost elements such as special and premium pays may not be applicable to all occupational specialties.

Table 1

MILITARY OCCUPATIONS CONVERTED TO CIVILIAN
(By Air Force specialty)

AFSC	Title	No. Converted
291	Telecommunications Operations Specialist	1106
472	Base Vehicle Equipment Mechanic	174
473	Vehicle Body Mechanic	408
511	Computer Systems Operator	428
542	Electrician	199
545	Refrigeration & Air Conditioning Specialist	279
547	Heating Systems Specialist	268
551	Pavement Maintenance Specialist	700
552	Carpentry, Masonry, Plumbing Specialist	699
553	Site Development Specialist	115
555	Programs & Work Control Specialist	201
563	Sanitation Specialist	173
571	Fire Protection Specialist	1194
602	Passenger & Household Goods Specialist	194
603	Vehicle Operator/Dispatcher	268
611	Supply Services Specialist	110
622	Cook	805
631	Fuel Specialist	114
645	Inventory Management Specialist	808
647	Material Facilities Specialist	550
651	Procurement Specialist	125
671	General Accounting Specialist	143
702	Administration Specialist	1528
732	Personnel Specialist	150
741	Athletic/Recreation Specialist	159
902	Medical Service Specialist	104
906	Medical Administrative Specialist	389

Table 2

MILITARY AND CIVILIAN COST ELEMENTS BY CATEGORY

Cost Element	Military	Civilian
Salary		
Basic Pay	X	X
Quarters	X	(a)
Subsistence	X	
Income Tax Adjustment	X	
Special & Premium Pays		
Hostile Fire	X	
Hazardous Duty	X	
Diving	X	
Certain Places	X	(a)
Reenlistment Bonus	X	
Proficiency Pay	X	
Special Pay to Medical Personnel	X	
Separation Pay	X	(a)
Overtime		X
Supplemental Benefits		
Retirement	X	X
Dependency & Indemnity	X	
Death Gratuity	X	
Social Security	X	X
Medical	X	
Health Benefits		X
Workmen's Compensation		X
Mortgage Insurance	X	
Terminal Leave	X	X
Unemployment Compensation	X	X
V.A. Educational Benefits	X	
Noncompensation Personnel Costs		
Clothing Allowance	X	
Personal Money Allowances	X	
Dislocation Allowances	X	
Overseas Station Allowances	X	
Burial Costs	X	
Life Insurance (SGLI)	X	X
Permanent Change of Station	X	
Training	X	
Support Costs	X	X

[a]Civilian personnel assigned overseas receive quarters and special pays not included in the cost data in Table 3.

Annual by-grade cost factors for officer, enlisted, general schedule civilian, and wage grade personnel are provided in Table 3.[a] These cost factors were obtained from the Air Force input to the DoD report, *Economic Cost of Military and Civilian Personnel in the Department of Defense* (March 1974). Costs for all elements listed in Table 2 except family separation allowances, station allowances, incentive pay, and special pay are included in these cost factors. The Air Force input data were used here because they included an adjustment to civilian retirement costs to account for the present discounted value of future liabilities. Civilian retirement costs in the DoD report applied a percentage factor to cover the value of the employing agencies' contribution to the Civil Service Retirement Fund and therefore did not recognize the unfunded liability of that fund. Military retirement costs were also developed on the basis of the present value of future liabilities, there-

Table 3

COMPARATIVE COST FACTORS FOR MILITARY AND CIVILIAN PERSONNEL[a]

Military			General Schedule		Wage Cost	
Grade	Cost 1	Cost 2[b]	Grade	Cost	Grade	Cost
0-10	58,320	65,902				
0-9	55,965	63,240	GS-18	43,845		
0-8	52,560	59,393	GS-17	43,845		
0-7	46,247	52,259	GS-16	43,845		
0-6	40,198	45,424	GS-15	40,378		
0-5	33,480	37,824	GS-14	34,371	WG-14	17,210
0-4	28,723	32,457	GS-13	29,373	WG-13	16,781
0-3	22,661	25,607	GS-12	24,937	WG-12	15,740
0-2	18,513	20,920	GS-11	21,112	WG-11	15,212
0-1	15,055	17,012	GS-10	19,347	WG-10	14,524
E-9	22,353	25,259	GS-9	17,592	WG-9	13,817
E-8	19,499	22,034	GS-8	16,160	WG-8	13,086
E-7	17,112	19,337	GS-7	14,579	WG-7	12,641
E-6	15,076	17,036	GS-6	13,446	WG-6	12,020
E-5	12,995	14,684	GS-5	11,976	WG-5	10,980
E-4	11,677	13,195	GS-4	10,545	WG-4	10,559
E-3	10,903	12,320	GS-3	9,147	WG-3	10,220
E-2	10,632	12,014	GS-2	7,588	WG-2	9,755
E-1	10,164	11,485	GS-1	6,610	WG-1	9,107

[a] A complete summary of the derivation of these cost factors, including source references, will be provided by the author upon request.

[b] Cost 2 = 1.13 X Cost 1 to include an allowance for the military support space factor.

[a] Wage grade supervisory and leader positions were not analyzed because of their infrequent occurrence in the sample.

by accounting for the full value of the unfunded military retirement system.

AIR FORCE EXPERIENCE

Using an Air Force data track of more than 14,000 positions that were civilianized between FY 1973 and FY 1975, it is possible to examine the hypothesis that an optimum mix of military and civilian resources did not exist before the civilian substitution program. For each military position converted to civilian, four data elements were tracked: Air Force specialty, military grade, civilian occupational series, and civilian grade. From these elements, data links were formed between military grade and civilian grade within each represented Air Force specialty. Further, a check against the civilian occupational series was possible to verify equivalency of job content.

Up to now, most of the theoretical discussion of how to determine the optimum mix has been directed toward Air Force requirements. However, total requirements are an aggregation of the requirements within specific functions and Air Force specialties. If the focus is narrowed to the level of the three-digit Air Force Specialty Code (AFSC), each military grade may be linked through conversion to a civilian grade. Again, assuming that the value of the contribution to defense missions were equal before and after the conversion action, within a specified grade only those conversion actions that yield a workload performed by a less costly resource would be a movement toward an optimum mix of military and civilian manpower. If conversion actions within a given military grade are found for which civilian manpower proves to be less costly than military manpower, then these conversion actions move the mix in the direction of the optimum.[5] It may be further concluded that there was no optimum mix before the conversion actions.

If conversion actions are found for which civilian manpower proves to be more costly than military manpower, then in these instances the result is away from the optimum mix.

The cost data set forth in Table 3 permit a comparison of cost factors between military and civilian grades. Of 14,171 Air Force military positions identified for conversion to civilian between FY 1973 and FY 1975, 6,834 were converted to general schedule (GS) civilian positions, 3,816 were converted to wage grade (WG) nonsupervisory positions, 837 were converted to wage grade supervisory (WS) and

[5] This conclusion implies that a less costly military resource could not be found to perform the same workloads. The civilian substitution programs precluded reducing the grade of military resources required to perform workloads to be civilianized.

leader (WL) positions, and 1,254 were converted to foreign national (FN) positions. Data for the remaining 1,430 positions were found to be incomplete or incorrect and therefore not appropriate for further analysis. Also, because of the small number of wage grade supervisory and leader positions in a given AFSC, further analysis of these positions was not conducted.

The Appendix presents the number of positions by military grade converted to each civilian grade for a selected set of Air Force specialties. Table 4 is a summary of the 10,650 military positions converted to GS and WG nonsupervisory positions. The solid lines identify the civilian grades for which the cost factors in Table 3 are above and below the military factor for Cost 1. The dashed lines represent the breakpoint between military and civilian grades when military cost is increased by 13 percent to cover the military support space requirement. Using Cost 1 from Table 3 as the breakeven cost of conversion, the percent of conversions to a GS civilian grade above the breakeven cost ranges from 1.9 percent for Telecommunications Operators to 64.8 percent for the Pavement Maintenance and Construction Equipment occupations. For positions converted to WG civilians, the percent of conversions above the breakeven cost ranges from 37 percent for the Inventory Management specialty to 60 percent for the Fire Protection, Pavement Maintenance, and Construction Equipment occupations. When Cost 2 is used as the breakeven cost of conversion, the percent of conversions to a GS civilian grade ranges from 0.1 percent for Telecommunications Operators to 48.1 percent for the Pavement Maintenance and Construction Equipment occupations. Similarly, for WG civilians, the percent of conversions above the Cost 2 breakeven point ranges from 12 percent for the Inventory Management specialty to 36.8 percent for Fire Protection. Hence, as would be expected, when the breakeven cost is increased to cover the military support space cost, the percent of cost-effective conversions increases, while the percent of conversions above the breakeven point decreases. However, the variance of conversions above and below the breakeven cost appears more concentrated in specialties that have a uniformity of tasks, such as Telecommunications and Administration, than in specialties that cover a wide variety of tasks, such as Pavement Maintenance and Construction Equipment. Also, some of the conversions were not to comparable civilian positions. For example, in Table A.1 a lieutenant colonel telecommunications position was converted to a GS-5, administrative secretary position. Although noncomparable conversions did occur, they were the exception rather than the rule.

As shown in Tables 4 and 5, at least 60 percent of the conversions from military to civilian positions were in the direction of a lower-cost resource and thus, other things being equal, in the direction of the

Table 4

Military to Civilian Conversions by Grade: FY 1973-FY 1975

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	1	0	0	1
GS14	1	0	0	0	1	0	0	0	12	8	6	0
GS13	2	3	9	1	1	0	0	5	51	22	5	0
GS12	4	14	12	5	7	2	8	16	64	23	3	0
GS11	9	10	28	33	22	12	9	12	74	13	3	0
GS10	0	0	0	5	1	1	1	1	4	3	0	0
GS09	10	21	33	110	62	21	11	19	61	10	2	0
GS08	7	3	9	24	14	8	2	4	8	0	0	0
GS07	56	85	124	179	75	10	3	41	29	7	0	0
GS06	34	70	124	83	27	2	0	2	3	0	0	0
GS05	267	378	330	158	57	7	2	2	9	5	1	0
GS04	456	435	368	82	14	0	1	1	4	0	1	3
GS03	783	604	319	53	10	1	0	1	3	1	1	0
GS02	247	193	86	6	2	1	0	0	0	0	0	0
GS01	5	11	3	1	1	0	0	0	0	0	0	0
WG14	0	0	0	0	0	0	0	0	0	0	0	0
WG13	1	0	0	1	1	1	0	0	0	0	0	0
WG12	1	14	9	5	1	0	0	0	0	0	0	0
WG11	16	19	33	16	7	0	0	0	0	0	0	0
WG10	261	265	215	12	3	1	0	0	0	1	0	0
WG09	202	141	105	9	0	0	0	0	0	0	0	0
WG08	330	157	93	7	2	0	0	0	0	0	0	0
WG07	180	98	51	6	1	0	0	0	1	0	0	0
WG06	245	90	56	16	2	0	0	0	0	0	0	0
WG05	387	174	107	8	2	0	0	0	0	0	0	0
WG04	65	19	16	3	0	0	0	0	0	0	0	0
WG03	168	20	16	1	0	0	0	0	2	1	0	0
WG02	111	15	2	0	1	0	0	0	0	0	0	0
WG01	15	5	3	0	0	0	0	0	0	0	0	0

Table 5

CONVERSIONS ABOVE BREAKEVEN COST
(percent)

AFSC	Above Cost 1	Above Cost 2
291	1.9	0.1
551	60.7	22.8
571	38.3	7.3
645	18.3	4.6
702	10.9	5.5
All	40.2	16.7

optimum mix for the specialties subjected to conversion. Yet, even when allowance is made for the military support space cost, Cost 2 (shown by the dashed lines in Table 4), a significant number of conversion actions are to a higher-cost resource. In this table, 713 (10 percent) of the military positions converted to GS civilian positions were converted to a higher-cost resource. The problem is worse in the WG category, where 1,061 (28 percent) of the positions converted to the wage grade nonsupervisory schedule were to a higher-cost resource. Of the total 10,650 military positions converted to GS or WG nonsupervisory positions, 1,774 (16.7 percent) were converted to a higher-cost resource. If the validity of applying the support space factor only to the military is challenged, then the proportion of conversions to a more expensive resource increases to 40 percent of those military positions converted to GS or WG positions.

While the military budgets incremental manpower to cover requirements for training, transients, personnel support, medical care, welfare, recreation, and other base operating support, the federal government also incurs a cost for these same activities for civilians. In fact, through such programs as the national scholarship and loan programs, the federal revenue sharing programs, the National System of Interstate and Defense Highways, the National Park Service, income tax deductions for medical expenses, and federal grants to states for welfare and public assistance programs, the government incurs a significant cost of support activities for civilian in-house and contract personnel. Although it is difficult to allocate these support costs to a particular manpower position (military or civilian), the cost of that position is not reduced. Instead, it is necessary to qualify what costs can be identified and estimated on a comparable basis for each type of manpower resource, while recognizing that there are additional costs.

SUMMARY AND CONCLUSIONS

Traditionally, cost has not been a criterion in the process for determining the mix of military and civilian manpower. Rather, the Air Force, at the direction of the OSD, has followed a policy of placing civilians in all positions not requiring military incumbency. However, during the late 1960s and early 1970s, the OSD forced several civilianization programs on the services, with a view to reducing manpower costs. In particular, between FY 1973 and FY 1975, the Air Force converted more than 14,000 military spaces to civilian positions. These conversion actions were made without considering whether the conversions were less costly, and they biased the manpower mix in the direction of civilian manpower relative to the mix that would have obtained had cost entered the determination process.

Because approximately 60 percent of the civilian conversion actions were to a less costly resource, it may be concluded that at least in selected specialties, the substitution program yielded a movement in the direction of the optimum mix of military and civilian, other things being equal. However, more than 40 percent of the conversion actions were to a more expensive resource. In those specialties where the predominant conversion was to a more costly resource, it must be concluded that the civilian substitution program moved away from the optimum mix, other things being equal.

If the DoD is to use the least costly resource consistent with defense requirements, the criterion of cost will need to be added to the criterion of essential military manpower. A consistent costing method will have to be applied to military and civilian resources performing similar functions. Costs peculiar to a military occupational specialty or a civilian job series will have to be identified and quantified to provide a basis for management decisions that determine the mix of military, civilian, and contract manpower.

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Appendix

MILITARY TO CIVILIAN CONVERSIONS BY GRADE

Table A.1

AFSC 291 TELECOMMUNICATIONS OPERATIONS

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	0	0	0	0
GS14	0	0	0	0	0	0	0	0	0	0	0	0
GS13	0	0	0	0	0	0	0	0	0	0	1	0
GS12	0	0	0	0	0	0	0	0	0	1	0	0
GS11	0	0	0	0	0	1	0	0	0	0	0	0
GS10	0	0	0	0	0	0	0	0	0	0	0	0
GS09	0	0	0	1	0	0	0	0	0	0	0	0
GS08	0	0	0	0	0	0	0	0	0	0	0	0
GS07	0	0	1	3	3	0	0	0	0	0	0	0
GS06	0	0	0	8	3	0	0	0	0	0	0	0
GS05	1	11	4	10	1	1	0	0	0	0	1	0
GS04	13	56	34	13	1	0	0	0	0	0	0	0
GS03	160	246	79	11	0	0	0	0	0	0	0	0
GS02	57	33	15	1	0	0	0	0	0	0	0	0
GS01	3	10	3	0	0	0	0	0	0	0	0	0

Table A.2

AFSC 551 Pavement Maintenance & Construction Equipment

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	0	0	0	0
GS14	0	0	0	0	0	0	0	0	0	0	0	0
GS13	0	0	0	0	0	0	0	0	0	0	0	0
GS12	1	0	0	0	0	0	0	0	0	0	0	0
GS11	0	0	0	0	0	0	0	0	0	0	0	0
GS10	0	0	0	0	0	0	0	0	0	0	0	0
GS09	3	0	0	0	0	0	0	0	0	0	0	0
GS08	0	0	0	0	0	0	0	0	0	0	0	0
GS07	10	0	1	0	0	0	0	0	0	0	0	0
GS06	12	0	1	0	0	0	0	0	0	0	0	0
GS05	7	0	1	0	0	0	0	0	0	0	0	0
GS04	9	1	0	0	0	0	0	0	0	0	0	0
GS03	7	0	1	0	0	0	0	0	0	0	0	0
GS02	0	0	6	0	0	0	0	0	0	0	0	0
GS01	0	0	0	0	0	0	0	0	0	0	0	0
WG14	0	0	0	0	0	0	0	0	0	0	0	0
WG13	0	0	0	0	0	0	0	0	0	0	0	0
WG12	0	0	0	0	0	0	0	0	0	0	0	0
WG11	3	0	0	0	0	0	0	0	0	0	0	0
WG10	7	3	2	0	0	0	0	0	0	0	0	0
WG09	5	3	0	0	0	0	0	0	0	0	0	0
WG08	90	23	6	0	0	0	0	0	0	0	0	0
WG07	16	12	3	0	0	0	0	0	0	0	0	0
WG06	137	24	0	2	0	0	0	0	0	0	0	0
WG05	41	8	0	0	1	0	0	0	0	0	0	0
WG04	20	2	0	0	0	0	0	0	0	0	0	0
WG03	127	9	2	0	0	0	0	0	0	0	0	0
WG02	59	1	0	0	0	0	0	0	0	0	0	0
WG01	10	0	0	0	0	0	0	0	0	0	0	0

Table A.3

AFSC 571 Fire Protection

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	0	0	0	0
GS14	0	0	0	0	0	0	0	0	0	0	0	0
GS13	0	0	0	0	0	0	0	0	0	0	0	0
GS12	0	0	0	0	0	0	0	0	0	0	0	0
GS11	0	0	0	0	1	0	0	0	0	0	0	0
GS10	0	0	0	0	0	0	0	0	0	0	0	0
GS09	0	3	0	0	0	0	0	0	0	0	0	0
GS08	4	0	0	1	0	0	0	0	0	0	0	0
GS07	9	4	10	0	2	0	0	0	0	0	0	0
GS06	6	30	89	5	0	0	0	0	0	0	0	0
GS05	134	93	78	0	0	0	0	0	0	0	0	0
GS04	236	54	34	0	0	0	0	0	0	0	0	0
GS03	207	13	15	1	0	0	0	0	0	0	0	0
GS02	4	4	3	0	0	0	0	0	0	0	0	0
GS01	0	0	0	0	0	0	0	0	0	0	0	0
WG14	0	0	0	0	0	0	0	0	0	0	0	0
WG13	0	0	0	0	0	0	0	0	0	0	0	0
WG12	0	0	0	0	0	0	0	0	0	0	0	0
WG11	0	0	1	0	0	0	0	0	0	0	0	0
WG10	15	1	2	0	0	0	0	0	0	0	0	0
WG09	3	0	0	0	0	0	0	0	0	0	0	0
WG08	5	1	1	0	0	0	0	0	0	0	0	0
WG07	3	1	0	0	0	0	0	0	0	0	0	0
WG06	4	4	4	0	0	0	0	0	0	0	0	0
WG05	5	4	4	0	0	0	0	0	0	0	0	0
WG04	2	2	2	0	0	0	0	0	0	0	0	0
WG03	5	2	0	0	0	0	0	0	0	0	0	0
WG02	0	5	0	0	0	0	0	0	0	0	0	0
WG01	0	0	0	0	0	0	0	0	0	0	0	0

Table A.4

AFSC 645 Inventory Management

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	0	0	0	0
GS14	0	0	0	0	0	0	0	0	0	0	0	0
GS13	0	0	0	0	0	0	0	0	0	0	0	0
GS12	0	0	1	0	1	0	0	0	0	0	0	0
GS11	0	2	2	1	0	0	0	0	0	0	0	0
GS10	0	0	0	0	0	0	0	0	0	0	0	0
GS09	0	0	2	8	6	0	1	0	0	0	0	0
GS08	0	1	1	0	1	0	0	0	0	0	0	0
GS07	2	2	5	17	6	1	0	0	0	0	0	0
GS06	1	2	4	17	1	1	1	0	0	0	0	0
GS05	19	34	31	21	1	0	0	0	0	0	0	0
GS04	70	56	45	15	0	0	0	0	0	0	0	0
GS03	76	24	16	6	0	0	0	0	0	0	0	0
GS02	11	3	6	0	0	1	0	0	0	0	0	0
GS01	0	0	0	0	0	0	0	0	0	0	0	0
WG14	0	0	0	0	0	0	0	0	0	0	0	0
WG13	0	0	0	0	0	0	0	0	0	0	0	0
WG12	0	1	0	0	0	0	0	0	0	0	0	0
WG11	0	0	0	0	0	0	0	0	0	0	0	0
WG10	0	0	1	0	0	0	0	0	0	0	0	0
WG09	0	0	0	0	0	0	0	0	0	0	0	0
WG08	5	3	0	0	0	0	0	0	0	0	0	0
WG07	4	1	0	0	0	0	0	0	0	0	0	0
WG06	13	12	14	3	0	0	0	0	0	0	0	0
WG05	1	1	4	2	0	0	0	0	0	0	0	0
WG04	2	4	1	0	1	0	0	0	0	0	0	0
WG03	3	1	3	1	0	0	0	0	0	0	0	0
WG02	2	0	0	0	0	0	0	0	0	0	0	0
WG01	0	0	0	0	0	0	0	0	0	0	0	0

Table A.5

AFSC 702 Administration

Grade	A1C	SGT	SSG	TSG	MSG	SMS	CMS	LT	CPT	MAJ	LTC	COL
GS18	0	0	0	0	0	0	0	0	0	0	0	0
GS17	0	0	0	0	0	0	0	0	0	0	0	0
GS16	0	0	0	0	0	0	0	0	0	0	0	0
GS15	0	0	0	0	0	0	0	0	0	0	0	0
GS14	1	0	0	0	0	0	0	0	0	0	0	0
GS13	1	0	1	1	0	0	0	0	0	0	0	0
GS12	1	1	2	2	0	0	0	0	2	0	0	0
GS11	2	0	0	0	2	0	0	0	0	0	0	0
GS10	0	0	0	2	0	0	0	0	0	0	0	0
GS09	3	3	0	15	3	0	0	1	4	1	0	0
GS08	0	0	2	1	2	0	0	0	1	0	0	0
GS07	3	8	5	18	9	1	0	1	9	0	0	0
GS06	1	8	3	13	2	0	0	0	1	0	0	0
GS05	7	37	30	39	10	0	0	0	2	0	0	0
GS04	20	60	63	18	6	0	0	0	0	0	0	0
GS03	154	174	116	13	5	0	0	0	0	0	0	0
GS02	130	95	51	2	0	0	0	0	0	0	0	0
GS01	1	1	0	0	0	0	0	0	0	0	0	0
WG14	0	0	0	0	0	0	0	0	0	0	0	0
WG13	1	0	0	0	0	0	0	0	0	0	0	0
WG12	0	1	0	0	0	0	0	0	0	0	0	0
WG11	0	0	0	0	0	0	0	0	0	0	0	0
WG10	2	1	0	0	0	0	0	0	0	0	0	0
WG09	0	1	1	0	0	0	0	0	0	0	0	0
WG08	0	1	1	0	0	0	0	0	0	0	0	0
WG07	1	0	0	0	0	0	0	0	0	0	0	0
WG06	2	1	0	0	0	0	0	0	0	0	0	0
WG05	0	0	0	0	0	0	0	0	0	0	0	0
WG04	0	0	0	0	0	0	0	0	0	0	0	0
WG03	0	0	0	0	0	0	0	0	0	0	0	0
WG02	12	1	1	0	0	0	0	0	0	0	0	0
WG01	0	0	0	0	0	0	0	0	0	0	0	0

MAINTENANCE PERSONNEL EFFECTIVENESS IN THE NAVY

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The contribution of personnel of different kinds to effectiveness is an important unknown in military manpower research. Knowledge of the likely productivity of enlisted men is crucial for developing personnel policy. In the absence of this knowledge, policies regarding manning, recruitment, assignment, rotation, and pay are essentially arbitrary.

This study employs regression analysis to associate crew characteristics with various measures of performance. Because of the type of data available, the output measures are largely maintenance-oriented. The ship subsystems studied include guns, boilers, torpedoes, sonars, and ASROCs. After correcting for other relevant variables, the relationship between the level of maintenance of these subsystems and the education, experience, ability, and in-service training of the personnel responsible for maintaining them is estimated.

INTRODUCTION

Very little is known about the relative performance of personnel who differ in education, experience, ability, training in the Navy, and race. Efficient allocation of Navy personnel requires that variations in productivity among individuals reflect variations in their cost. Knowledge of how personnel differences are likely to contribute to differences in effectiveness is necessary for rigorous analysis of Navy policies regarding the level of manning, recruitment, assignment, rotation, and pay.

This paper will focus on maintenance as an activity contributing to effectiveness. If we are successful in attributing variations in the level of maintenance among ships to differences in the make-up of the portion of the crew responsible for maintenance, we will have made an important step toward more informed analysis of defense manpower issues.[1] Our results support the hypothesis that the composition of a ship's crew is an important factor in explaining its condition.

A MODEL OF SHIP MAINTENANCE

The amount of time that equipment fails to function in a specified time period can be expected to depend on the age of the ship, the length of time since the ship was last overhauled, the proportion of time the ship is under way, equipment complexity, and manning. We use multiple linear regression techniques to estimate the relationship between shipboard equipment failures and their hypothesized determinants.

To assure a reasonably homogeneous sample, we have confined our examination to destroyers. The sample includes all the active destroyers that underwent overhauls in FY 1972, FY 1973, and FY 1974—40 ships in all. To be sure that we were looking at comparable periods on all the ships, and because of data limitations, only equipment failures in the 18 months before overhaul were considered.[2] Whenever a ship suffers an equipment failure that degrades its operational capability, the ship must file a casualty report (CASREPT). We have used CASREPT information to derive our measures of maintenance effectiveness.[3] The number of CASREPTs per ship, total time that CASREPTs remained outstanding (total downtime), and the portion of downtime that was not spent waiting for parts (maintenance downtime) were all used as dependent variables in the analysis. Our measure of maintenance downtime is the total time elapsed before the repair is made (aside from waiting for parts). It includes both the time spent making repairs and the delay in getting to repairs.

Rather than study the determinants of CASREPTs for entire ships, we concentrated on several subsystems, chosen because they are common to a large number of destroyers and are maintained by men in a small number of enlisted occupations (ratings). The subsys-

[1] This perspective agrees with that of G. Nelson, R. Gay, and R. Roll, *Manpower Cost Reduction in Electronic Maintenance: Framework and Recommendations*, The Rand Corporation, R-1483-ARPA, July 1974.

[2] The data we used on equipment failure were not available for the period before 1970.

[3] CASREPT information is kept on an automated file system at the Navy Fleet Material Support Office (FMSO) in Mechanicsburg, Pa. FMSO also provided information on the tempo of ship operations, as measured by the proportion of months in which the ship was under way.

tems we have focused on are boilers, engines, gun systems, antisubmarine warfare (ASW) systems, and sonars. Table 1 shows the ratings of the personnel who are responsible for the maintenance of these subsystems. The same ratings are sometimes responsible for part of the maintenance of more than one subsystem. To match men and equipment properly, it was necessary to allocate CASREPTs by rating, rather than by subsystem.

Table 1

SUBSYSTEMS BEING STUDIED

Subsystem	Associated Rating
Boilers	Boiler Technician (BT)
Engines	Machinist's Mate (MM)
Gun systems	Fire-Control Technician (FT) Gunner's Mate (GM)
ASW systems	Gunner's Mate (GM) Sonar Technician (ST) Torpedoman's Mate (TM)
Sonars	Sonar Technician (ST)

In the equipment failure data that we received, every CASREPT was classified according to the equipment identification code (EIC) of the piece of equipment being reported. By examining the EICs, we assigned every relevant CASREPT to one of the six ratings we are concentrating on: boiler technician (BT); machinist's mate (MM); fire-control technician (FT); gunner's mate (GM); torpedoman's mate (TM); and sonar technician (ST).[4]

For a small number of EICs, we were unable to determine which of the deck ratings (FT, GM, ST, or TM) was likely to be responsible for maintenance. We assigned these to no rating but lumped them in with all the EICs assigned to the deck ratings in forming an additional category, total deck.

The enlisted manning characteristics that we were able to examine for our designated ratings are shown below:

Number of enlisted personnel
Pay-grade profile
Standard deviation of the manning level

[4] FMSO supplied a tape from the 3-M data system of all corrective maintenance actions taken on our 40 ships since 1970. This tape included information on who performed every action. We derived frequency counts of repair ratings for all relevant EICs, which allowed the assignment of rating categories.

Specialized training
Schooling of junior enlisted personnel

The number of officers on board was also included in the analysis.[5] The number and duration of CASREPTs should vary inversely with the number of enlisted pesonnel. A higher proportion of senior enlisted personnel should be associated with fewer maintenance failures. We felt that the standard deviation of the manning level was likely to be related to the amount of crew turnover. More turnover probably leads to more variation in the manning level. Rapid turnover is felt to detract from a crew's knowledge of its ship and may thus lead to more maintenance problems.

The completion of certain advanced training courses confers Navy Enlisted Classifications (NECs) on graduates. We used the number of primary and secondary NECs that men possessed as a measure of the extent of advanced training.

All enlisted personnel who reach the level of third-class petty officer (E-4) are members of some rating. When men finish boot camp they go either to school or directly to the fleet, where their further training is on the job. Those who go to school are more likely to be designated as being associated with a particular rating than are the others. The proportion of E-3s and E-2s who are not designated was taken to be a measure of the prevalence of on-the-job training as opposed to formal schooling.

It was impossible to include measures of pre-Navy school experience, entry test scores, or race in the current analysis. We are now using the Navy's Enlisted Master Record to create a longitudinal history of the manning of the ships in our sample. This history will allow us to study additional personnel characteristics and to get better measures of some of the characteristics we have been able to include here.

For each of the seven rating groups (six ratings plus total deck) we estimated a relationship of the following form:

$$C_i = f(\text{age, ovh diff, und, steam, } \overline{\text{yr}}, \overline{\text{class}}, \text{off}, \overline{\text{pers}_i}) \qquad (1)$$

where C_i = one of three measures of maintenance effectiveness (number of CASREPTs, total downtime (hours), or maintenance downtime (hours)) for rating group i,

age = age of the ship at the time of its overhaul (years) in FY 1972-1974,

[5] The enlisted personnel data came from semiannual BuPers Report 1080 (Enlisted Distribution and Verification Report) forms that are filled out regularly by every ship. Officer data came from Officer Distribution Control Report (ODCR) forms.

ovh diff = number of months between overhauls,
und = fraction of months in which the ship was under way,
steam = average number of steaming hours in the months in which the ship was under way,
$\overline{yr}$ = a vector of three dummy variables reflecting the year (FY 1972, 1973, or 1974) in which overhaul was performed,
$\overline{class}$ = a vector of dummy variables reflecting the class of the ship,
off = the number of officers on board, and
$\overline{pers_i}$ = a vector of the enlisted personnel variables enumerated in Table 2 for rating group i.

It was expected that newer ships would have fewer CASREPTs, other things being equal.

A longer gap between overhauls should lead to more maintenance problems. If it doesn't, ships are being overhauled too frequently. A faster tempo of operation, as reflected by more intensive steaming, may also be associated with more CASREPTs. However, when a ship is out of port its crew has fewer competing demands for its time and may perform better maintenance, leading to fewer CASREPTs and less downtime.[6] Since informal Navy policy regarding CASREPT reporting may vary from year to year, overhaul dummies were included to correct for differences across ships in the observation period.

Different classes of ships vary to some extent in their equipment. Obviously, this may influence ships' maintenance histories. In particular, the new Forrest Sherman class destroyers are known to have had more boiler problems because of technical innovations in their design. Because of the differences between Forrest Sherman and other destroyers, we allowed for the possibility that personnel contributions to maintenance effectiveness were different for Forrest Sherman ships than for other destroyer classes.[7] Finally, more officers may lead to better supervision and hence fewer maintenance problems.

We estimated Eq. (1) using ordinary least squares. As noted earlier, the period of observation for the dependent variables was the 18 months before overhaul. For the independent variables, the entire time between overhaul in FY 1972, FY 1973, or FY 1974 and a ship's previous overhaul was the period of observation. The level of mainte-

[6] The same arguments can be made about the fraction of months in which a ship is under way.

[7] This was done by multiplying each personnel variable by both a Forrest Sherman class dummy and a dummy for other ships. The two variables were entered separately into the equation being estimated. If this procedure did not improve the explanatory power of the equation, its results were discarded.

nance is a stock concept rather than a flow concept; the condition of a piece of equipment depends not only on the care the equipment is getting now but also on the care it received in the past. By using a longer observation period for the independent variables than for the dependent variable, we hoped to capture the long-run effects of variation in the determinants of maintenance effectiveness.[8]

EMPIRICAL RESULTS

In this section the results of estimating Eq. (1) for each of the seven rating groups will be treated in turn. The independent variables differ across rating groups because variables that did not improve the corrected R^2 of either the CASREPT or total downtime equation were deleted.

Both linear and semilogarithmic forms for the regression were tested. Many of the variables appeared to predict best in a linear framework. Some of the most important variables, such as the number of personnel, seemed to have a semilogarithmic relationship with maintenance. This implied decreasing returns to personnel. More men appear to improve maintenance, but as extra men continue to be added, the contribution of the last man decreases. The proportion of men in senior pay grades also seems to exhibit diminishing returns.[9]

Boiler Technicians

Table 2 shows the results for BTs. Newer ships have fewer boiler maintenance problems, other things being equal—although Forrest Sherman ships, as expected, have more trouble than others.

Personnel factors matter considerably. As the elasticity estimate shows, a 1 percent increase in the number of BTs is estimated to be associated with a 5.28 percent decrease in total boiler downtime on Forrest Sherman ships and a 9.47 percent decrease on others.[10] More turnover, as measured by the standard deviation variable, seems to lead to less effective boiler maintenance, at least on non-Forrest Sherman ships.

[8] For reasons discussed later, in the TM regressions, only the 18-month period was used for the personnel variables.

[9] Ship age is also logarithmically related to maintenance. Older ships are worse than newer ones, other things being equal, but they are depreciating at a lower rate.

[10] In all cases, the elasticity figures in the tables refer to the percent effect on the dependent variable of a 1 percent change in the raw value of the independent variable, even if the logarithm of the independent variable has been used in the regression. All elasticities were calculated at the means of the variables.

Table 2

DETERMINANTS OF THE LEVEL OF MAINTENANCE EFFECTIVENESS FOR BOILER TECHNICIANS

Independent Variable	Dependent Variable: Number of CASREPTs	Total Downtime (hours)	Maintenance Downtime (hours)
Personnel-related variables			
Non-Forrest Sherman class destroyers			
Logarithm of the average number of BTs			
Coefficient	-26.84	-34832	-33371
t-value	- 1.09	- 1.61	- 1.90[a]
Elasticity	- 4.16	- 9.47	-10.61
Standard deviation of BT manning level			
Coefficient	1.77	1550	1420
t-value	1.88[a]	1.86[a]	2.10[b]
Elasticity	0.61	0.97	1.04
Forrest Sherman class destroyers			
Logarithm of the average number of BTs			
Coefficient	-34.70	-82351	-58935
t-value	- 0.90	- 2.41[b]	2.12[b]
Elasticity	- 2.34	- 5.28	- 4.49
Non-personnel-related variables			
Logarithm of ship age			
Coefficient	29.14	43644	34647
t-value	1.66	2.81	2.74[b]
Elasticity	3.59	7.57	7.08
Number of months between overhauls			
Coefficient	0.15	13.40	-14.04
t-value	1.20	0.12	- 0.16
Elasticity	0.69	0.09	- 0.11
Forrest Sherman class dummy			
Coefficient	53.89	190262	113503
t-value	0.38	1.51	1.11
Elasticity	1.16	5.78	4.06
FY 1973 overhaul dummy			
Coefficient	- 0.78	- 2816	- 2253
t-value	- 0.34	- 1.37	- 1.35
Elasticity	- 0.03	- 0.17	- 0.16
FY 1974 overhaul dummy			
Coefficient	3.83	8461	9394
t-value	0.55	1.37	1.87[a]
Elasticity	0.01	0.04	0.05
Constant	-14.30	-33550	- 8141
Corrected R^2	0.31	0.56	0.58
Degrees of freedom	31	31	31

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

Machinist's Mates

Machinist's mates perform organizational-level maintenance on ship propulsion machinery. The regression results for MMs are displayed in Table 3.

As in the case of boilers, the engine CASREPT behavior of older ships is worse than that of newer ships. A larger complement of MMs seems to lead to fewer CASREPTs, particularly on Forrest Sherman

Table 3

DETERMINANTS OF THE LEVEL OF MAINTENANCE EFFECTIVENESS FOR MACHINIST'S MATES

	Dependent Variable		
Independent Variable	Number of CASREPTs	Total Downtime (hours)	Maintenance Downtime (hours)
Personnel-related variables			
All destroyers			
Fraction of unrated personnel who are not designated			
Coefficient	5.57	7890	5427
t-value	0.69	1.13	0.90
Elasticity	0.14	0.32	0.27
Non-Forrest Sherman class destroyers			
Logarithm of the average number of MMs			
Coefficient	-37.25	-27117	-24704
t-value	- 2.15[b]	- 1.83[a]	- 1.93[a]
Elasticity	- 3.48	- 4.16	- 4.62
Logarithm of the fraction of MMs who are E-5 and above			
Coefficient	- 8.06	-28268	-22684
t-value	- 0.78	- 3.18[c]	- 2.96[c]
Elasticity	- 0.76	- 4.33	- 4.24
Forrest Sherman class destroyers			
Logarithm of the average number of MMs			
Coefficient	-30.14	-16058	-17113
t-value	- 1.75[a]	- 1.08	- 1.34
Elasticity	- 3.70	- 2.77	- 4.45
Non-personnel-related variables			
Logarithm of ship age			
Coefficient	34.74	18952	10103
t-value	2.31[b]	1.47	0.91
Elasticity	3.39	2.96	1.99
Carpenter class dummy			
Coefficient	-11.40	- 5200	- 4526
t-value	- 2.09[b]	- 1.11	- 1.12
Elasticity	- 1.11	- 0.81	- 0.89
Constant	3.00	507	26427
Corrected R^2	0.19	0.24	0.19
Degrees of freedom	33	33	33

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

[c] Significant at the 1 percent level.

ships. Unlike boilers, engines may have fewer problems in Carpenter class ships.[11]

Most interesting, for non-Forrest Sherman class destroyers, the pay-grade profile of MMs is the most important determinant of total downtime, although it is only a minor factor in explaining the number of CASREPTs. This may mean that although senior MMs don't prevent many CASREPTs, they get the equipment fixed quicker. On these ships, a 1 percent increase in the proportion of MMs who are chiefs, first class petty officers, or second class petty officers (E-5 and above) is estimated to decrease total engine downtime by 4.3 percent.

It appears likely that sending more MMs to entry-level schools also decreases the amount of engine downtime.

Fire-Control Technicians

Fire-control technicians are responsible for the maintenance of weapons control and targeting equipment. Their job is among the most complex in the Navy. FTs are highly trained and must have very high entry test scores. Table 4 shows the estimated determinants of CASREPTs for FTs.

The equations for FTs are the best we estimated. The R^2s are higher than for the other rating groups, and the personnel variables play an even larger role than they do elsewhere. Perhaps personnel characteristics are most important in the most highly technical ratings.

The fire-control systems of older ships and ships long out of overhaul have relatively bad maintenance records, as do ships that were overhauled in FY 1972.

The number of FTs aboard has a large effect on total fire-control downtime. This result is so statistically significant that it is almost impossible for it to be due to chance. More senior FTs very likely lead to both fewer CASREPTs and less downtime. More turnover may be associated with more downtime on non-Forrest Sherman ships, and there is evidence that the level of FT training, as measured by the prevalence of NECs, is a determinant of fire-control downtime. FTs are the only rating for which this last variable appears important.

Gunner's Mates

Gunner's mates perform maintenance on guns and missiles, al-

[11] The sample includes only one Carpenter class ship, and anecdotal evidence indicates that it was well maintained because it had a well-motivated crew, not because of its design.

Table 4

Determinants of the Level of Maintenance Effectiveness for Fire Control Technicians

Independent Variable	Dependent Variable: Number of CASREPTs	Total Downtime (hours)	Maintenance Downtime (hours)
Personnel-related variables			
All destroyers			
Logarithm of the fraction of FTs who are E-5 and above			
Coefficient	- 4.24	- 2732	- 2276
t-value	- 2.93[c]	- 2.11[b]	- 2.46[b]
Elasticity	- 0.69	- 0.77	- 1.01
Number of primary and secondary NECs divided by number of FTs			
Coefficient	- 1.30	- 3764	- 1029
t-value	- 0.48	- 1.54	- 0.59
Elasticity	- 0.13	- 0.65	- 0.28
Non-Forrest Sherman class destroyers			
Logarithm of the average number of FTs			
Coefficient	- 7.90	-14436	- 9793
t-value	- 2.25[b]	- 4.81[c]	- 4.37[c]
Elasticity	- 1.48	- 4.48	- 4.43
Standard deviation of FT manning level			
Coefficient	0.35	1263	1168
t-value	0.42	1.69	2.19[b]
Elasticity	0.09	0.52	0.71
Forrest Sherman class destroyers			
Logarithm of the average number of FTs			
Coefficient	1.55	- 6901	- 5327
t-value	0.52	- 2.61[b]	- 2.81[c]
Elasticity	0.16	- 1.37	- 2.13
Non-personnel-related variables			
Logarithm of ship age			
Coefficient	21.87	11672	6423
t-value	2.90[c]	1.74[a]	1.34
Elasticity	3.87	3.30	2.84
Number of months between overhauls			
Coefficient	0.20	121	73
t-value	3.25[c]	2.22[b]	1.86[a]
Elasticity	1.23	1.28	1.21
FY 1973 overhaul dummy			
Coefficient	- 2.86	- 1685	- 1159
t-value	- 2.59[b]	- 1.71[a]	- 1.61
Elasticity	- 0.16	- 0.17	- 0.18
FY 1974 overhaul dummy			
Coefficient	- 5.24	- 5033	- 2744
t-value	- 1.88[a]	- 2.03[a]	- 1.55
Elasticity	- 0.02	- 0.04	- 0.03
Constant	-61.51	-12797	- 5235
Corrected R^2	0.58	0.57	0.53
Degrees of freedom	30	30	30

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

[c] Significant at the 1 percent level.

though fire-control system maintenance is largely left to FTs. Our regression results for GMs are displayed in Table 5.

Personnel factors were not significant in explaining the number of CASREPTs. The extent of downtime, however, is influenced by the skill mix of GMs. The level of experience necessary to improve GM-related maintenance seems to vary by class of ship. On Forrest Sherman class destroyers, GMs appeared to reach their maximum proficiency when they became rated (pay grade E-4). On other destroyers, this maximum was not reached until men became first class petty officers (E-6). This interclass difference in the relationship between pay grade and proficiency is probably due to differences between the gun systems of Forrest Sherman ships and those of other destroyers. Other personnel variables, such as the average number of GMs, did not appear to affect the amount of equipment downtime. This may mean that the number of GM billets could be cut without significantly affecting equipment downtime. Gun maintenance also appears to be independent of GM turnover. This may be because guns have few ship-specific idiosyncracies.

Ships that were out of overhaul longer had more gun CASREPTs (though, oddly, not more downtime). Forrest Sherman ships had more gun problems than other ships, and GM-related CASREPTs also seemed to vary with overhaul year.

Torpedoman's Mates

Torpedoman's mates perform maintenance on underwater ordnance such as torpedoes and antisubmarine rockets. Although the level of skill required of a TM is below that required of an FT, TM personnel factors do affect the amount of time that antisubmarine weapons are inoperative, as shown in Table 6. When more TMs are present, repairs seem to be made faster. In addition, rated TMs (E-4 and above) seem to do a better maintenance job than junior personnel. Note that in other ratings where the pay-grade profile enters our regressions (MM, FT, GM, ST, and TD), the pay level that was associated with increased proficiency is either E-5 or E-6, with the exception of GMs on Forrest Sherman ships. Apparently TMs learn their jobs earlier than men in other ratings.

Ships that steamed more intensively had fewer TM CASREPTs. In this rating at least, the hypothesis that competing interests degrade maintenance is supported.

As was the case with GMs, the length of time since the last overhaul seems to affect the number of CASREPTs, but not downtime. Ships that were overhauled in FY 1972 reported more CASREPTs than those overhauled in later years.

Table 5

DETERMINANTS OF THE LEVEL OF MAINTENANCE EFFECTIVENESS FOR GUNNER'S MATES

Independent Variable	Dependent Variable: Number of CASREPTs	Dependent Variable: Total Downtime (hours)	Dependent Variable: Maintenance Downtime (hours)
Personnel-related variables			
Non-Forrest Sherman class destroyers			
Logarithm of the fraction of GMs who are E-6 and above			
Coefficient	- 0.80	- 8995	- 7388
t-value	- 0.26	- 3.51[c]	- 3.75[c]
Elasticity	- 0.15	- 2.34	- 3.15
Forrest Sherman class destroyers			
Logarithm of the fraction of GMs who are E-4 and above			
Coefficient	-32.56	-59551	- 8719
t-value	- 0.89	- 1.96[a]	- 0.37
Elasticity	- 2.59	- 6.71	- 1.54
Non-personnel-related variables			
Number of months between overhauls			
Coefficient	0.12	9.36	- 7.87
t-value	1.38	0.13	- 0.14
Elasticity	0.67	0.07	- 0.11
Forrest Sherman class dummy			
Coefficient	4.56	10073	14303
t-value	0.56	1.49	2.74[b]
Elasticity	0.12	0.37	0.85
FY 1973 overhaul dummy			
Coefficient	0.53	1367	728
t-value	0.36	1.13	0.78
Elasticity	0.03	0.10	0.09
FY 1974 overhaul dummy			
Coefficient	-13.24	- 7959	- 5994
t-value	- 3.15[c]	- 2.29[b]	- 2.24[b]
Elasticity	- 0.06	- 0.04	- 0.05
Constant	- 0.35	-11088	- 9191
Corrected R^2	0.43	0.47	0.40
Degrees of freedom	33	33	33

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

[c] Significant at the 1 percent level.

Table 6

DETERMINANTS OF THE LEVEL OF MAINTENANCE EFFECTIVENESS FOR TORPEDOMAN'S MATES

Independent Variable	Dependent Variable: Number of CASREPTs	Dependent Variable: Total Downtime (hours)	Dependent Variable: Maintenance Downtime (hours)
Personnel-related variables (all destroyers)			
Logarithm of the average number of TMs[d]			
Coefficient	- 0.05	- 1124	- 614
t-value	- 0.10	- 1.52	- 1.20
Elasticity	- 0.08	- 1.67	- 1.55
Logarithm of the fraction of TMs who are E-4 and above			
Coefficient	- 0.32	- 1288	- 592
t-value	- 0.73	- 1.95[a]	- 1.30
Elasticity	- 0.51	- 1.91	- 1.50
Non-personnel-related variables			
Average number of steaming hours in months in which the ship is under way			
Coefficient	- 0.008	-13.59	- 6.10
t-value	- 2.12[b]	- 2.25[b]	- 1.46
Elasticity	- 3.54	- 5.57	- 4.26
Number of months between overhauls			
Coefficient	0.03	1.01	0.83
t-value	1.42	0.04	0.04
Elasticity	1.80	0.06	0.08
FY 1972 overhaul dummy			
Coefficient	0.48	811	451
t-value	1.47	1.64	1.32
Elasticity	0.48	0.75	0.71
Constant	1.06	4224	2002
Corrected R^2	0.11	0.30	0.14
Degrees of freedom	34	34	34

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

[c] Significant at the 1 percent level.

[d] In these regressions the personnel variables refer only to the 18 months before overhaul, rather than the entire interoverhaul period. This was done because better estimates were obtained. Perhaps there is little carryover from one period to the next in the level of TM-related maintenance.

Sonar Technicians

Sonar technicians on destroyers operate and maintain surface sonar and oceanographic equipment and underwater fire-control equipment. In Table 7, sonar casualties are seen to be more prevalent in older ships and perhaps in ships that have been under way more. This is reasonable, since sonars operate only when the ship is under way. A large complement of STs and a higher proportion of ST chiefs and first and second class petty officers seem to contribute to better mainte-

Table 7

Determinants of the Level of Maintenance Effectiveness for Sonar Technicians

Independent Variable	Dependent Variable		
	Number of CASREPTs	Total Downtime (hours)	Maintenance Downtime (hours)
Personnel-related variables			
All destroyers			
Fraction of unrated personnel who are undesignated			
Coefficient	7.32	8085	4440
t-value	1.51	2.26[b]	1.75[a]
Elasticity	0.13	0.25	0.25
Standard deviation of ST manning level			
Coefficient	1.97	1035	506
t-value	2.90[c]	2.07[b]	1.43
Elasticity	0.88	0.82	0.76
Non-Forrest Sherman class destroyers			
Logarithm of the average number of STs			
Coefficient	- 4.91	- 5221	- 2547
t-value	- 1.62	- 2.34[b]	- 1.60
Elasticity	- 1.3[illegible]	- 2.81	- 2.79
Logarithm of the fraction of STs who are E-5 and above			
Coefficient	- 6.23	- 3782	- 1478
t-value	- 1.29	- 1.06	- 0.59
Elasticity	- 1.69	- 2.02	- 1.82
Non-personnel-related variables			
Fraction of months in which the ship is under way			
Coefficient	10.94	9661	5019
t-value	1.34	1.61	1.18
Elasticity	2.52	3.95	3.85
Logarithm of ship age			
Coefficient	12.30	15336	7163
t-value	1.37	2.33[b]	1.54
Elasticity	3.26	7.20	6.32
Constant	-42.88	-49286	-23010
Corrected R^2	0.19	0.25	0.13
Degrees of freedom	33	33	33

[a]Significant at the 10 percent level.

[b]Significant at the 5 percent level.

[c]Significant at the 1 percent level.

nance on non-Forrest Sherman class ships, but not on Forrest Sherman ships.

Higher ST turnover is associated with significantly more CASREPTs and more downtime on all destroyers. The presence of undesignated men in ST billets also significantly degrades maintenance.

Total Deck Rating Group

The total deck group is the sum of FTs, GMs, STs, and TMs. This aggregation was performed to let us include CASREPTs that could not be attributed to one rating but were the responsibility of more than one rating in the group in the sample. The results of this procedure are shown in Table 8. Older ships and ships long out of overhaul had more problems in the deck ratings.

The two most consistently important personnel variables, the average number of personnel and the proportion of personnel who are second class petty officers or higher, were significant determinants of downtime in the deck ratings for all destroyers. The prevalence of senior enlisted personnel seems to be more important in Forrest Sherman class ships than in other destroyers. A 1 percent rise in the fraction of deck personnel who are E-5s or above can be expected to decrease deck downtime by over 4 percent in Forrest Sherman ships, but only 2 percent in other destroyers.

Table 9 presents a digest of our results regarding the influence of personnel factors on total downtime. Total downtime is the most complete measure of the inability of equipment to do its job that we have examined.

The final two tables illustrate how the regression estimates can be used to facilitate policy decisions. Table 10 shows the effect of adding an extra man in each of the rating groups. It implies that BT-related maintenance could be improved at no cost in ship condition elsewhere by adding an extra BT while cutting the complement of GMs by one.

Table 11 examines several ways of improving FT-related maintenance. By applying the relevant cost factors to estimates like these, the most efficient policy for improving maintenance can be chosen from among the listed alternatives.

CONCLUSIONS

Personnel factors affect the level of maintenance of a wide range of subsystems, although different characteristics are important in different occupations. In general, personnel characteristics may play a larger role in the effectiveness of men in more highly technical ratings.

Table 8

DETERMINANTS OF THE LEVEL OF MAINTENANCE EFFECTIVENESS FOR THE TOTAL DECK RATING GROUP

Independent Variable	Dependent Variable: Number of CASREPTs	Total Downtime (hours)	Maintenance Downtime (hours)
Personnel-related variables			
All destroyers			
Logarithm of the average number of deck personnel			
Coefficient	-14,75	-28294	-19210
t-value	- 0,68	- 1,68	- 1,72[a]
Elasticity	- 0,84	- 2,53	- 2,82
Non-Forrest Sherman class destroyers			
Logarithm of the fraction of deck personnel who are E-5 and above			
Coefficient	- 8,47	-20005	-14311
t-value	- 0,83	- 2,52[b]	- 2,72[b]
Elasticity	- 0,55	- 2,05	- 2,39
Forrest Sherman class destroyers			
Logarithm of the fraction of deck personnel who are E-5 and above			
Coefficient	-52,35	-83562	-49106
t-value	- 1,82[a]	- 3,75[c]	- 3,32[c]
Elasticity	- 1,91	- 4,67	- 4,58
Non-personnel-related variables			
Logarithm of ship age			
Coefficient	18,45	40201	18038
t-value	0,77	2,18[b]	1,47
Elasticity	1,66	3,59	2,65
Number of months between overhauls			
Coefficient	0,36	217	106
t-value	2,33[b]	1,83[a]	1,35
Elasticity	0.77	0,73	0.58
Average number of steaming hours in months in which the ship is under way			
Coefficient	- 0,004	-53,86	- 3233
t-value	- 0,10	- 1,67	- 1,51
Elasticity	- 0,06	- 1,33	- 1,31
FY 1974 overhaul dummy			
Coefficient	-17,32	- 9808	- 6562
t-value	- 2,08[b]	- 1,52	- 1,53
Elasticity	- 0,02	- 0,02	- 0,02
Constant	-15,29	-38186	3307
Corrected R^2	0,36	0,45	0,40
Degrees of freedom	32	32	32

[a] Significant at the 10 percent level.

[b] Significant at the 5 percent level.

[c] Significant at the 1 percent level.

Table 9

PERSONNEL FACTORS AND EQUIPMENT DOWNTIME

	BT	MM	FT	GM	TM	ST	Total Deck
Non-Forrest Sherman class destroyers							
Average number of personnel	*	**	****		*	***	****
Standard deviation of the number of personnel	**		*			***	
Fraction of personnel E-4 or above					**		
Fraction of personnel E-5 or above		****	***			*	***
Fraction of personnel E-6 or above				****			
Prevalence of primary and secondary NECs			*				
Prevalence of undesignated personnel		*				***	
Forrest Sherman class destroyers							
Average number of personnel	***	*	***		*		**
Standard deviation of the number of personnel						***	
Fraction of personnel E-4 or above				**	**		
Fraction of personnel E-5 or above			***				****
Prevalence of primary and secondary NECs			*				
Prevalence of undesignated personnel		***				***	

*Enters the equation.

**Significant at the 10 percent level.

***Significant at the 5 percent level.

****Significant at the 1 percent level.

Table 10

REDUCTION IN DOWNTIME DUE TO ADDITION OF ONE EXTRA MAN

	BT	MM	FT	GM	TM	ST	Weapons
Percent							
Non-FS	41%	19%	56%	0	58%	25%	16%
FS	22	13	12	0	32	0	4
Hours							
Non-FS	1509	1240	1805	0	400	465	1563
FS	3429	773	602	0	495	0	716
Average On-Board							
Non-FS	22	21	7	9	2	11	30
FS	24	20	11	12	2	11	36

Table 11

ALTERNATIVE WAYS OF CUTTING FT-RELATED DOWNTIME BY 100 HOURS PER YEAR ON FORREST SHERMAN CLASS SHIPS

Increase average manning level	From 10.9 to 11.1
Increase percent of FT's E-5 or above	From 47 to 49 percent
Increase average number of primary and secondary NECs on board	From 8.59 to 9.08
Decrease interoverhaul period	From 38 months to 37 months

The influence of personnel on maintenance also varies with the class of ship.

- Crew size is important in almost all ratings, but the extent to which it matters seems to vary considerably by rating. Manning levels were much more important for BTs and FTs than for GMs.
- In some ratings, particularly STs, excessive turnover seems to detract from maintenance.
- Ships with a higher proportion of senior personnel are better maintained, although the necessary level of experience varies by rating.
- The measures of training that we examined appeared important for some ratings. We picked up an effect for FTs, MMs, and STs, but not for the other rating groups.

Factors other than personnel also affect the level of maintenance:

- Older ships require more maintenance.
- Ships that go longer between overhauls require more maintenance in several subsystems.
- The tempo of ship operations affects maintenance performance in some ratings, though the direction of the effect varies.

It would be useful to estimate the effect of other personnel factors, such as education, race, and test scores, on maintenance effectiveness. It would also be useful to have better measures of Navy training and crew turnover than we used in this study. Further research is indicated, and we will be using the Navy Enlisted Master Records to perform some of it. In addition to incorporating more and better measures of personnel characteristics, we will experiment with alternative functional forms. We will also incorporate another 51 cruiser/destroyer ships into the sample. Finally, we will examine additional measures of maintenance effectiveness, most prominently findings of the Board of Survey and Inspection.

Although this work is preliminary, it illustrates our approach. Our quantitative findings will both change and expand, but the results presented here provide estimates of the ways in which personnel affect ship maintenance.

MANPOWER REQUIREMENTS IN A DYNAMIC SETTING

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In the all-volunteer environment, the need for efficient force composition and military compensation is acute. Manpower planning of compensation is one obvious vehicle for affecting force composition. New bonus programs and other forms of special pay in fact allow the services to vary the effective level of compensation, but the current structure is not optimal. The dynamic or short-term management of the force by compensation is extremely important for several reasons. Moving from today's force toward the objective force requires dynamic analysis, since changing technology and requirements constantly change the concept of the objective force structure. Discounting decreases the importance of the steady state and increases the relative weight decisionmakers put on the short-term policies.

The objective of the model developed here is to minimize the present cost of operating the system, subject to an effectiveness constraint in each of the periods over the finite planning horizon. Dynamic programming is used to find the best manpower compensation and resulting force structure for a military system for each of a number of years. Discrete approximation to the states and actions, aggregation of the force by term of service, and decision periods of four years' length facilitate the description of the decision process as a Markov chain. A numerical example is also discussed.

INTRODUCTION

One of the key elements of defense manpower planning is manpower requirements. It is necessary to know the total numbers and mix of personnel to determine the ability to achieve both the defense mission and defense costs. Traditionally, analyses of manpower requirements have focused on either the very short run, such as the requirements for next year's budget cycle, or the very long run, such as the optimal "steady-state" manpower configuration. Such analyses usually shed little light on the best way to move from today's force mix to the desired mix or even whether the purported savings warrant the costs of adjusting.

This paper specifically considers how manpower requirements can be planned over time. A dynamic optimization model explicitly optimizes force structures over time. Most manpower models view personnel planning in the steady state, but the dynamic planning approach allows the analyst, and indeed the policymaker, to determine the "best" way of solving requirements planning when time is explicitly introduced into the problem.

National security objectives are regularly interpreted by the Department of Defense (DoD) in an annual planning process. It is here that missions are assigned and the capabilities to perform them are established as objectives in each of the services. Aggregate manpower requirements necessary to fulfill these national security goals are expressed in the five-year defense plan, the result of an iterative planning cycle of developing requirements for civilian, officer, and enlisted personnel within each of the services. This process does not lend itself to finding an optimal mix of manpower. In the often frantic budgeting process, the manpower mix to achieve a particular mission cannot be optimized. At best, linear and average costing methods combined with intuition are used to set the mix. Ultimately it must be specified by military specialty, grade, and length of service. Traditional steady-state factors are used to construct a grade distribution or length of service distribution to meet the mission.

In the requirements determination and personnel management systems, little thought can be given to the integration of year-to-year requirements with the objective force. Mission schedules derived indirectly from the five-year defense plan are used to determine requirements for manpower to maintain capability during these missions. Specification of requirements is made independently of current force structure and the structure of an objective force. Personnel management is charged with planning for training, transfers, cross-training, and career field continuance, to name but a few items. The goal here is to meet these requirements for men specified in each specialty, pay grade, etc. Requirements and personnel management are at best suboptimization processes within a larger hierarchy of decisionmaking.

Congress sets grade limitations, manning level constraints, levels of pay, and a total manpower budget. It is at this level that the objective force structure is established and approved and becomes objectives and constraints for service planners. However, several mixes of manpower would meet national security objectives. In fact, there is an optimal mix. What is that mix? Once answers are known, a requirements structure can be developed that is consistent with efficiency. General guidance in this area would specify important policy considerations such as ratios of first term to career, tradeoffs on education and mental aptitude, etc.

Today's structure has developed from both good and bad decisions made in the past. The current inventory of men and women cannot be changed without cost. The cost of an optimal mix is an important consideration in determining that mix and the policy actions necessary to get from here to there.

This study was undertaken to provide general methodology for setting and changing requirements consistent with both the long-term optimal force and the current structure. The approach is one that has a dynamic view of moving from present to desired size and mix. The vehicle for the study was a manpower model that determined the optimal length of service distribution of an enlisted force as it changes over a finite planning period.

Manpower models are becoming an increasingly important tool for defense planners. For the most part, these models focus on steady-state force structures. This concept of a desirable, attainable, objective force structure differentiated by length of service (LOS), pay-grade level, and possibly even by skill and military specialty has evolved over the past decade. The modeling efforts useful in determining that structure were stimulated by requests from the Office of the Secretary of Defense (OSD) in the late 1960s for the services to develop long-range manpower plans.

Unfortunately, these models have left the policymaker with the problem of how to achieve this steady-state optimum. He is given no idea of the advantages of this objective force over the present force structure. Are the benefits of the optimum worth the costs of getting there? This question has not been answered.

This paper considers how manpower requirements can be planned to vary over time, explicitly developing strategies to determine how the current force structure should be changed to achieve the long-run optimum. A model will be proposed that reflects changing retention behavior as a function of changing wages. The objective is to minimize the present worth of costs of operation of the manpower part of the military system. The solution to this mathematical formulation can be found by dynamic programming. The feasibility of the approach is demonstrated by the testing of a realistic numerical example.

Means for estimating the cost differential between current policy and one found from dynamic optimization are available through the various manpower models. Although no conclusive results are presented, this paper does discuss method, including relevant factors for policymakers.

There is no theoretical difficulty with extending this approach to management of just one military specialty. The aggregate force free of constraints is modeled here, but the techniques are valid and practicable for subelements within the force.

Recent developments affecting military manpower indicate the importance of systematic and comprehensive management in planning of military forces. Manpower costs as a proportion of the DoD budget have risen dramatically in the past decade, from 27.7 percent in 1964 to 30.3 percent in 1974.[1] Part of the cost increase is due to the all-volunteer force, which officially began 1 July 1973 but actually started with the formation of the President's Commission on an All-Volunteer Armed Force in 1969. An important effect of the all-volunteer force is the elimination of a guaranteed supply of enlistments through the Selective Service System. Although all military services except the Marine Corps have been at full strength in the past two years, the uncertainty of enlistments under the all-volunteer force places a premium on careful planning and good manpower management.

The OSD directives on developing manpower plans indicate the interest in and importance placed on manpower planning. Long-range plans in the form of an objective force structure have been developing using mathematical models. But planning does not end with knowing where to go. Research must find the best way to get there. In fact, many analysts believe that managing the military force in a steady state simply can never be achieved, and that that objective should be abandoned. The arguments are persuasive: The character of the pool of men who may volunteer is constantly changing. International and national economics and current events are undergoing continual change, which affects the reenlistment and enlistment tendency for the military. Requirements for men and women in the services vary according to the missions outlined by defense policy and technological change.

The shorter-term results of decisionmaking are of dominating importance for two reasons. First, when costs and revenues are discounted in the time period in which they occur, those from the shorter term are given higher weight in the total discounted cost function. Second, many decisionmakers reflect the political environment in which they operate and put a higher weight on shorter-term effects of their decisions.

The reliability of present data on supply of manpower and project-

[1] *Budget of the United States*, 1964 and 1974.

ed requirements is subject to uncertainty. These data are used to provide estimates of parameters that crucially affect the optimal policy. Estimates of the near future are simply more reliable than speculations about 20 years hence.

Basic uncertainty about the future is often taken into account by business decisionmakers by using a discount rate higher than that used for more certain projects. The fact that decisionmakers discount the future further emphasizes the importance of the shorter-term decisions. The discount rate takes into consideration the time value of money as well as the added uncertainty. Even if the objective force is constantly changing because of uncertainty and the randomness of future events, discounting will lessen the effect of a variance of the steady-state component of a policy from the true optimum. This reduces the effect that such inaccuracies might have on calculating the short-term optimal decisions.

THE POLICY PROBLEM

This paper describes a model designed to address the problem of optimal manpower structure over the short term before a steady state may be reached. Behavioral assumptions to regulate the supply of manpower, productivity assumptions about the effectiveness of a military structure, and discounting to consider uncertainty and the time value of money are three important features of this model.

The behavioral assumption is that decisionmakers can manage retention policy by LOS class through the application of economic incentives. This has been demonstrated as practicable by the success of the new bonus authority available to the services. Bonuses may now be paid in particular specialties at initial enlistment, at first reenlistment, and at second reenlistment, with total bonuses for a military career being as high as $30,000.

The current method of affecting the age and experience composition of the force is through the assignment of the bonus at different levels in the various specialties needing increased retention. Increased quality requirements can be used to restrict the number qualified in specialties where there is an oversupply of potential reenlistees. Grade management is conducted primarily to satisfy grade-level constraints and fulfill requirements. However, retention is dependent on promotion policy because of changes in income and other factors experienced by the force under different promotion policies. In reality, several manpower policies directly and indirectly affect retention and therefore the experience composition of the force; but here, compensation has been chosen as the determinant of retention.

In the long run, changing real wages to influence retention is more efficient than curtailing the reenlistment of qualified individuals. Although pay levels are set by Congress and might not be thought of as variable, changes in the structure of the military pay system may be possible as result of experience with the all-volunteer force. Within the past ten years, the following radical changes have, in fact, occurred in the military compensation system: comparability pay increases (1967-1969); special pay programs, such as the variable reenlistment bonus (1966) and the combat enlistment bonus (1971); and the all-volunteer force pay increases for first-termers (1971).

A companion issue to direct military compensation is military retirement. Changes in this system are currently under consideration. The retirement system has an effect on the composition and structure of the military force—men approaching 20 years of service have near 100 percent retention rates, and men who have just become eligible for retirement pay have high loss rates. The effect on retention and losses of such changes as a partial vesting of retirement benefits must be considered by military manpower planners.

As already mentioned, several pecuniary and nonpecuniary means are available and have been used in the past. These packages of bonuses, tour lengths, educational benefits, etc., have been somewhat effective in managing force structure. The policy questions addressed here allow for changing the force LOS structure and possibly grade and skill as well. The proposed vehicle for these changes is through changing pay variables.

Whether the fixed costs of changing the current retention management system to one based on the economic behavioral model outweigh the advantages has not been determined. The means for making such an evaluation are discussed in a later section.

New modeling developments using increased computational capability have been providing opportunities for much greater control and planning than was previously possible. The new complexity of policymaking, management, and planning can be demonstrated by the growing dependence of administrators, planners, and other decisionmakers, particularly in the DoD, on mathematical models of manpower and personnel systems. Within the past ten years, the military services and OSD have developed models to assist in the practice of grade management, in the making of promotion policies, in forecasting losses from the active force and requirements for new accessions, and in scheduling personnel inputs to training courses. These predictive models form the basis for policy simulation, which has been the major planning tool to date.

Optimization models developed for military manpower planning have not given manpower planners guidance on how best to get from the current to the desired force. The planning period, often called the transient period, is simply not addressed in steady-state models. Limiting the spread of these steady-state optimization models is the debate over whether a steady state will ever exist; and if not, why concentrate attention on trying to get there? However, if an optimal state is thought possible, how would we best get there from today's force structure? In either case, such a question can be addressed only by a dynamic optimization model that takes proper consideration of today's force structure, the costs of change over time, and possibly the eventual steady state.

Goal programming has been used successfully in military force planning models for planning in the short term. (See Charnes, Cooper, and Niehaus, 1972.) The technique and its optimal force plan are heavily dependent on critical assumptions about penalty weights used when goals are not met. To a large extent, these weights are chosen hypothetically with little or no economic or statistical foundation. In spite of these limitations, goal programming has been the only optimization procedure found to work for manpower planning within an overconstrained dynamic operating environment.[3]

Generally speaking, models developed to date are inadequate in balancing short- and long-range goals necessary to model the supply behavior and productivity of a military force. Desirable features of a more sophisticated model include (1) behavioral assumptions that modify historical retention rates as manpower decisions change wages, tour length, or promotion, and (2) production functions used in place in rigid requirements constraints.

THE MODEL

Productivity functions applied to the military have been discussed and used in earlier Rand work (Jaquette and Nelson, 1974) on an optimal static model and in the ADSTAP (Lehto et al., 1973) Naval enlisted personnel planning system. Productivity may simply be a measure of force size or some function of the force structure called military output or effectiveness. This military output is measured each year by a unidimensional productivity function of the number of men classified by length of service in that year. Here we assume that productivity $Q(x)$ is a function of the number of men in each year of service, x, where $x = (x_1, x_2, \ldots x_{30})$. The state of the system at any

[3] The advantages and disadvantages of goal programming, as well as those of other military manpower models in current use, are discussed in Jaquette, Nelson, and Smith (1977).

time t is described by the number of men in each length of service on active duty at that time. Thus **x** is a vector function of time and can generally be written as $\mathbf{x}(t) = (x_1(t), x_2(t), x_3(t), \ldots)$.

Manpower planning decisions taken year by year will be thought of as varying the level of the military compensation—a measure aggregating pay, fringes, and retirement—paid to personnel in each of the different LOSs. Enlistment and reenlistment in the mathematical form of a retention fraction $r_i(t)$ of the eligible pool indicate the fraction advancing in military service from LOS $i-1$ to i in year t. Although the total compensation structure may be thought to be under management control, a more practical concept of how management can affect the retention fraction might be through the level of special bonuses and pays given personnel in different LOSs. The ADSTAP optimization takes another approach. It uses a penalty for reduction in historical continuance rates (severance pay) and a penalty for increases in historical continuance rates (bonuses). Specific assumptions, in any case, must be made relating military retention to costs of control, in this case the cost of the compensation package.

Wages paid men of service length i in year t are decided in the year before and denoted by $w_i(t)$. In the twentieth year of service, $w_{20}(t)$ includes the then-present value of the retirement income stream received from retirement until death. It would be possible to model reenlistment behavior beyond year 20, but for initial conceptual simplicity a maximum career length of 20 years is assumed.

The future time stream of wages, including retirement value and the associated probabilities of receiving these wages, enters into the behavioral relationship that prescribes the retention fraction $r_i(t)$. The assumption made follows the Rand static optimization model. The present expected worth of future wages is a single variable function of retention probabilities, wages, fringes, and retirement from the present until some future departure from the military pay system. This aggregate measure of compensation is divided by a normalization factor to obtain an annual equivalent to the present expected worth, called $p_i(t)$, the perceived pay in year of service i at time period t. While the general form of retention $r_i(t)$ can be written as

$$r_i(t) = r_i(w_i(t), w_{i+1}(t), \ldots w_{20}(t)) ,$$

here it is assumed that a relationship using the annual pay perceived by the enlisted man can be used. Thus,

$$r_i(t) = r_i(p_i(t)) ,$$

with perceived pay

$$p_i(t) = \frac{w_i(t)+w_{i+1}(t)\cdot r_{i+1}(t)\cdot d_{i+1}+ \dots +w_{20}(t)r_{i+1}\cdot r_{i+2} \dots r_{20}d_{i+1} \dots d_{20}}{1+r_{i+1}(t)d_{i+1}+r_{i+1}r_{i+2}d_{i+1}d_{i+2}+ \dots +r_{i+1} \dots r_{20}d_{i+1} \dots d_{20}},$$

where d_i = discount factor for an individual of YOS $i-1$.

The need for military effectiveness or productivity over time is modeled as stationary, based on the notion that the "strength of the chain is equal to the strength of its weakest link." Under certain sets of assumptions this objective in productivity can be derived from a game-theoretic approach of competing forces. It is stated as "maximize the minimum effectiveness subject to contraints on annual budget costs." Under changing yearly circumstances the objective might take on max-min $(U_1(Q_1), U_2(Q_2), \dots)$, where the Us are weighting functions and the Qs the effectiveness of the military force in each year. The dual problem is of a form that minimizes the discounted present value of costs subject to a constraint on productivity Q,

$$Q(x(t)) \geq Q^* \quad \text{for all } t.$$

The important assumption is that military capability is not substitutable from one time to the next. That is, having $2Q^*$ productivity in the first of two years and none in the second is in no way equivalent to having constant Q^* military output in each of the two years, implying that productivity cannot be discounted over time.

Formally, we wish to *minimize*

$$\sum_{t=0}^{\infty} \alpha^{t+1} x(t+1) \cdot w(t)$$

subject to

$$Q(x(t)) \geq Q$$

for each $t = 1, 2, \dots \infty$, with α the discount factor $= (1/1+i)$, and i the yearly interest rate. Structural considerations within the model relate wages, pay, retention, and the state variable x. These are

$x(0) = (x_1(0), \dots)$ the initial inventory level,

$x(t) = (x_1(t), x_1(t-1)r_2(t), x_2(t-1)r_3(t), \dots),$

$r_i(t) = r_i(w_i(t), w_{i+1}(t), \dots w_{20}(t)) = r_i(p_i(t)).$

Initially, productivity is measured by the linear production function

$$Q(t) = \sum_{i+1}^{20} s_i x_i(t),$$

with linear weights s_i. In later generalizations of the model, a geometric (Cobb-Douglas) form and others will be tested. The linear form has been used in the Navy's optimization work (Lehto et al., 1973) as well as in the Rand static optimization model (Jaquette and Nelson, 1974).

Generally, a finite planning horizon, T, limits the range of t, $0 \leq t \leq T$. At the end of the planning period, state boundary conditions must be met. Initially, these terminal states are the optimal steady-state solution, and practically speaking, the output of the Rand static model is the input for the numerical example to follow. The true integer requirements for the state variable x(t) are relaxed to simplify the calculations.

The Classical Solution

In the classical approach, the optimal values of decision variables $[w_1(t) \ldots w_{20}(t)]$, $t = 1, 2, \ldots T$, are found in the following constrained optimization:

Minimize

$$\sum_{t=1}^{T} \alpha^t w(t) \cdot x(t)$$

subject to

$$\sum_{i=1}^{20} s_i x_i(t) \geqslant Q$$

for each $t = 1, 2, \ldots T$.

State variable x is a function w and written as x(w(t)). One such relationship has been proposed in this model as

$$x(t) = (x_1(t), x_1(t-1) \cdot r_2(t), x_2(t-1)\, r_3(t), \ldots),$$

with $r_i(t) = r_i(w_i(t), \ldots, w_{20}(t)$, the retention behavior being a function of current wages in current and subsequent YOS classes. Using a perceived pay concept developed for the Rand static model, the effect of w_i through w_{20} is assumed to be achieved by a function $r_i(p_i(t))$.

Constrained optimization problems with nonlinear relationships are generally difficult to solve. The first-order conditions can be found by direct partial differentiation. Here, there are 20T variables, and even if decisions were made every four years and the state space were redefined to aggregate the number of men into terms of service, as is done in the Rand static optimization, the complex nonlinear nature of the retention behavior makes analytic differentiation difficult. Perhaps purely numerical differentiation and gradient methods may be the best way to find the minimum-cost dynamic force structure. The Navy's ADSTAP model uses such an optimization procedure in the static model of the Navy's enlisted force.

Constraints of the "greater than or equal to" form require analaysis of Kuhn-Tucker conditions. These conditions are derived from a mathematical requirement that arises in constrained nonlinear optimization. Applied in this example, they direct attention to sets of candidate solutions that satisfy modified first-order conditioning necessary for such a chosen trial solution to be optimal.

Exact equality of the productivity constraint may hold under certain conditions, but the general case may require that productivity occasionally exceed the minimum during the transient period. This is the primary reason that classical constrained optimization has been rejected at this point. Once an approximation to the optimal policy and force structure is obtained, then it may be desirable to return to this technique of numerical gradient search and resting of Kuhn-Tucker conditions to refine and improve the approximation.

The Dynamic Programming Formulation

Many nonlinear optimization problems can be formulated for solution by an iterative technique called dynamic programming. The procedure is to build solutions to larger problems with the known solutions to a smaller one. In this case, time will advance in discrete increments.

First, a one-period decision problem will be solved. This will be the planning period $(T-1)$, which goes from time $T-1$ until the final period T. It involves decisions on wages (and resulting retention) for only one period. Once this solution is known and stored within a computer as the value or cost at each of a finite number of possible starting-state conditions for $T-1$, the two-period program decision for time $T-2$ can be solved. Its solution is based on the costs previously calculated for period $T-1$. This procedure is replicated $T-1$ times, building the solution of the period t on that previously obtained for $t+1$.

For computational and demonstrational simplicity and following the example in the Rand static model, service personnel have been aggregated by LOS characteristics into terms of service. Thus, the 20-year career is divided into five 4-year-long terms of service. Reenlistment fractions, characterized by r, indicate the fraction of men in each term of service who are retained in the military and enter the next term of service. Discrete time is expressed in increments of four years. This eliminates the extensive bookkeeping that would be necessary if time jumps were of a different size.

Although these aggregations may seem severe at first, the model's computational ability and the types of solutions that can be obtained can be demonstrated using four-year-long groupings. The data needed for estimating the special enlistment and reenlistment parameters and the parameters of the productivity function are barely sufficient even for this example. Disaggregation to year groups will be justified when these data have been collected and additional refinement of the optimal solution is deemed desirable.

Let $G_t(x)$ be the minimum discounted present worth of the variable costs of manpower decisions from period t until T (starting from present state x) while maintaining the productivity constraint. Since current manpower decisions on wages to be paid cannot affect manpower levels today, but rather affect next period's force and its costs, it is assumed here that current wage decisions do not affect those now in service until they reach the next planning period. That is, the contract with those on board was made previously, and changes in wages are not allowed to take effect until the start of the next decision period. Current decisions then affect only the discounted operating costs plus the discounted cost of being in any state resulting from the current state x and current wage decisions, and do not affect the present period's operating costs. No loss of generality results from such assumptions.

The typical dynamic programming recursion that applies to this decision process is $G_t(x) = \text{minimum}\,[(w(t) \cdot x(t+1) + G_{t+1}(x(t+1))\alpha]$. The minimum is over a constrained set of wages such that $Q(x(t+1)) \geq Q^*$ in the next period. The current period's productivity, manpower force structure, and cost are unchanged by any current decision, because wages announced in period t are not paid until period t+1. Such a system leads to a model based on a Markov decision process, which then allows the use of dynamic programming as the solution technique. Other satisfactory ways to formulate the problem as a Markov process do exist, but the resulting optimal decisions and force structure would not be changed.

This recursion says that the optimal cost from the present state x in period t is the minimum over feasible wage policies (with resulting force structure) of the sum of wages per man times the number of men in each wage category who will receive the decision wage, plus the terminal cost of getting to the end of the planning horizon using whatever optimal rule is needed from the state resulting from the decision made on wages. All costs are properly discounted.

For computational purposes, the state and decision space must be reduced from the infinite number of alternatives possible to some countably finite number of alternatives by using a grid of permissible values as the allowable ranges for state and action. The optimization procedure resulting from the recursion is strictly numerical and the $G_{t+1}(x(t+1))$ for each $x(t+1)$ must be stored for ready access during the optimization search over feasible alternative decisions in period t.

This results in a model that will find an approximation to the truly optimal solution. The cost penalty of using the approximation is never known exactly; however, the error bounds on the optimal policy are only as wide as the grid and can be narrowed by using a finer grid in the region of the optimal solution. This will be a particularly effective means of improving the accuracy of the computational procedure.

The Solution to the Dynamic Programming Formulation

The solution technique is derived directly from the recursion formula. A realistic example is constructed that represents an extension of the Rand static model to the transient period—a 20-year (five decision periods) planning problem in the enlisted USAF. The applicability of the general dynamic programming approach is demonstrated by the example given here.

Wages and resulting enlistment and reenlistment rates in the force are to be determined for five periods of four years each. At the end of this time the system is required to be in the final state chosen arbitrarily to be optimal by the Rand static model. Productivity is measured using a linear production function with weight coefficients for the men in each YOS category. Retention behavior is a function of perceived pay. For this example, parameters for both the productivity and retention-fraction functions are taken from the Rand static optimization model.

The discount for personal discounting of future wages, d, is assumed to be .683 over four years (discount factor $= (1/1.1)^4 = .683$) for each term of service. This enters into the calculation of the pay perceived. The government's rate α is assumed to be 5 percent, which over a four-year period equals .823 ($i = .05$, $\alpha = 1/1.05$, $\alpha^4 = (1/1.05)^4 = .823$).

Productivity weights for the linear production function are .68, 1.0, 1.28, 1.513, and 1.755. Discrete approximation to any retention function curve the user may choose is possible. Supply functions that were required to be of an unusual S-shaped exponential curve for analytical purposes in the static optimization model are under no such constraint here. The perceived pay required to achieve any retention fraction needed is calculated by table-look-up with interpolation using 10 grid points. For the purposes of this example, the particular curves and their parameters were those of the Rand static model.

The optimal steady state under linear productivity was determined in previous Rand research to be about 228,000, 118,000, 93,000, 84,000, and 75,000 men, for a total of 598,000 men. Optimal steady-state productivity was about 650,000 units, given the linear production function. This steady-state force structure is used as the state boundary-condition constraint in which this dynamic model is required to end the 20-year period.

For the sake of illustration, the number of feasible staffing levels in each term of service was limited to five, making the state space of size 3,125 (five raised to the fifth power). These staffing levels are shown in Table 1.

Table 1

STATE SPACE TABLE

	State				
Term	1	2	3	4	5
1st	200,000	230,000	260,000	290,000	320,000
2nd	90,000	105,000	120,000	135,000	150,000
3rd	65,000	80,000	95,000	110,000	125,000
4th	55,000	70,000	85,000	100,000	115,000
5th	50,000	65,000	80,000	95,000	110,000

Because of the discrete nature of the state space, the chosen terminal state is (2,3,3,3,3) in terms of state indicator vector, or (230,000, 120,000, 95,000, 85,000, 80,000) in real state vector value, which approximates the calculated optimal steady state. The productivity requirement in every time period is set at 667,000 units, the same as in the final state, rather than 650,000, as under the optimal long-run force structure. The difference is a result of the discrete state space requirement in the present model.

Preliminary runs of the model using a FORTRAN program on Rand's IBM 370/158 computer have demonstrated the advantages and disadvantages of this approach for solving the dynamic manpower distribution. The results of the run enable one to trace through the optimal policy for each of the five decision periods before entering the terminal state (2,3,3,3,3). Table 2 shows a sample of such paths. Table 3 shows a sample and the information contained that is available as output for every decision period and from each of the (≈ 3,125) starting states feasible from that time period. The first line shows a starting state (2,3,3,3,3) with five decision periods prior to entering the terminal state (2,3,3,3,3). Optimal progression goes next to the (2,5,3,3,2) period in T−4 and continues as from the first line of Table 2.

Table 2

SAMPLE OPTIMAL TRAJECTORIES

	Period					
	T-5	T-4	T-3	T-2	T-1	T
Alternate Starting States	23333	→ 25332	→ 15432	→ 25422	→ 14442	→ 23333
	22442	25332	15432	25422	14442	23333
	55321	15432	25422	14541	13343	23333
	15432	22442	25332	25422	14442	23333
	14541	13343	35322	15432	24441	23333
		14541	13343	35322	15432	23333
		23333	25332	25422	14442	23333
			23333	25332	15432	23333
				23333	25332	23333

The supposed optimal steady state (2,3,3,3,3) determined by the Rand steady-state model under the same input parameters and basic assumptions is not optimal, as one would expect under this particular discrete optimization. Under the basic assumptions of both dynamic and static versions, the optimal steady state 23333 ought to be the optimal resulting state when starting from 23333 in each previous decision period. For example, in period 6, when starting in state 23333, the optimal wage package calls for an optimal resulting state of 25332 in period 5. If 23333 were the optimal stationary policy, the optimal policy for period 6 would call for movement to 23333. It appears that two-period-long oscillation occurs in the optimal policy with 22442, 25332, 15432 alternating before the last two decision periods when starting in a large set of states that includes 23333. This may be further evidence of the same problem; that is, a stationary policy remaining in 23333 is not optimal in this case.

One possible cause of the problem is the discrete nature of the state space. The grid spacing is perhaps too coarse. The objective function may be quite flat in the region near the optimal stationary rule and may exaggerate the effect of this discrete grid. Another possi-

Table 3

SAMPLE OUTPUT CONSOLIDATED FOR ONE TRAJECTORY

Period	Start State	End State, Optimal	Retention Rate					Perceived Pay ($ thousands)					Optimal Wage ($ thousands)				
T-5	23333	25332	.14	.65	.79	.89	.76	5.6	13.1	12.4	12.8	14.2	-1.2	13.8	11.9	12.1	14.2
T-4	25332	15432	.12	.65	.73	.89	.76	5.2	13.1	11.5	12.8	14.2	-1.6	14.6	10.4	12.1	14.2
T-3	15432	25422	.14	.75	.73	.64	.76	5.6	14.9	11.5	10.2	14.2	-3.0	17.6	12.4	8.2	14.2
T-2	25422	14442	.12	.59	.73	.91	.93	5.2	12.4	11.5	13.1	18.7	- .5	13.2	10.0	9.6	18.6
T-1	14442	23333	.14	.60	.70	.77	.80	5.6	12.5	11.3	11.2	14.7	.31	13.6	11.4	9.3	14.7

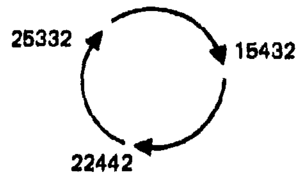

Fig. 1—Three-period cycling

bility is that the state represented by 23333 is not quite equal to the stationary optimal state under the state model. This itself may well result in oscillations of the dynamic optimal policy.

Justification of these preliminary conclusions could be made by sensitivity analysis. A range of terminal states near 23333 can be tested to see if slight variations will yield a stationary rule from that terminal state in earlier decision periods. The planning horizon can be extended out to 40 to 80 years (10 to 20 decision periods) to remove the influence of the terminal state to see if there is any stationary optimal state or states. This was conducted out to eight periods and similar patterns persisted.

I believe that these oscillations will be the rule rather than the exception and that they are caused by the discrete grid used to describe the state space. Repeated use of the dynamic progamming with a finer grid in the vicinity of the states through which the optimal policy will pass will be successful in reducing the importance of these oscillations. These oscillations will then be between adjacent states, with very small deviations in staffing levels required.

Another observation is the occurrence of a negative value for the optimal wage. On a theoretical basis, this is certainly a feasible outcome. In fact, it did occur intermittently for certain combinations of retention and perceived pay. Several interpretations can be made of this phenomenon; one is that the value of entering the career force is high enough to warrant an initial buy-in price to each enlistee. This cost may be thought of as the tuition paid for technical training, the value of which exceeds productivity during the first term.

Negative wages are not unheard of in the civilian sector, where students attend technical schools, colleges, and universities that charge a tuition or are subsidized through tax revenues. Certainly, there is some equivalence of career technical training in both the civilian and military labor market during a person's late teens and early 20s. Thus, negative wage in the first term of military service is not an altogether unreasonable concept. However, such an entrance fee could not realistically be charged each enlistee. What then is wrong? For the most part, the model is in error. The concept of perceived pay is one of the crucial assumptions driving retention behavior, and its validity needs further examination. The perceived-pay concept is based on an age-dependent discount rate. A high rate of 30 percent for first-termers, 10 percent for second-termers, and 5 percent beyond that was used. It is also based on an expectation of wages through a mathematical expected value. This concept is useful in reducing the multidimensional wage vector over the career to a single value called average perceived pay. Estimates of system parameters may be in error as well. Any misspecifications in these two areas could cause optimal wages to be negative. Without question, these important aspects of the model should be placed under careful review for possible modification.

The slightly irregular pattern of optimal military pay reported as an airman progresses through the career force is not as troublesome as it may appear. In fact, military compensation in any term of service can be thought of as the sum of regular wages, bonuses, and retirement vesting. Under the present system, reenlistment bonuses occur mainly in the second term, and retirement vesting occurs at 20 years. Smoothing out the take-home pay to achieve a nondecreasing paycheck as an airman ages is feasible under programs that would institute earlier and partial vesting of retirement benefits along the way.

The disadvantages of the dynamic programming approach taken here center on one factor: Computer time is approximately linearly related to the number of states chosen times the number of actions available from each state times the number of decision periods. In this program, the actions available were determined by observing the set of feasible resulting states. If there are n states used to characterize the state of the system and T periods of decision, the number of evaluations that must be made is of the order of n^2 multiplied by T. Here, using a grid of 5 in each term of service, the evaluations are of the order of 10^7. The present program stores very little information, keeping only the objective $G_t(x)$ for each of the 3,125 states of the previous time period. All information on optimal wage, retention, and pay from each state in each decision period is printed out. Core storage requirements are minimal, even though the computer time requirements are high.

The approach is still one of brute force. Refinements using external information to short-cut the evaluative process have improved the dynamic programming algorithms substantially. Preliminary runs that have been made with the data available, supplemented with rough estimates of productivity and retention parameters where none were available, have proven that the approach does work. It will be a feasible way to determine optimal transient policy in a general and rough sense. The limiting factor on usefulness is the size of the state space grid, which results in a rapidly increasing CPU time in proportion to n^3. Furthermore, it makes the sensitivity analysis previously suggested quite expensive.

Computer and analyst time and cost are insignificant contributors to the total cost of the proposed system. Large-scale changes in the retention behavior by use of pecuniary incentives are necessary to achieve the optimal trajectory of states. There are certainly hidden costs ignored in the present model that are incurred under a changing force mixture. The costs are thus extremely hard to estimate, as they include political as well as real costs.

The mathematical model itself is capable of providing an estimate of cost savings achievable under an optimal dynamic plan over the range of alternatives, which should include continuing the current accession and retention rates for minimum effectiveness or initiating the stationary policy necessary for the objective force structure and allowing the current force to age itself toward that objective.

Such a comparison can be made using the manpower flow model contained in the optimization model. Dynamic aging period by period using any desired wage, retention, etc., can be simulated and costs accumulated and properly discounted. (Modification of the computer code would be necessary to make such runs on the test example discussed here.) The potential savings are reasonably simple to estimate using the simulation capability of the basic manpower flow model.

Weighing the real plus subjective estimates of hidden political or organizational costs against the more quantitative savings estimate involves qualitative comparisons. A task force assembled to decide upon some or all of these personnel management tools would wrestle with such factors. A wide range of changes in manpower management philosophy should also be considered. The present bonus program is an example.

FURTHER RESEARCH

A continuing effort is being made to streamline the existing program with several computational shortcuts, although substantial improvement is expected. Experiments will be conducted, with the focus on obtaining a steady state. This will require examination of the static and dynamic models to see if the optimal transition pattern stabilizes. Many of the problems described are those that are to be expected in applications of dynamic programming. A discrete grid must be used to approximate the true state space. A need for accuracy demanding a large grid for the state space conflicts with the need for computational feasibility.

The classical approach will be studied to see if it is worthwhile to develop the nonlinear optimization algorithms necessary. The present approach has indicated that the productivity constraint holds in equality. In any decision period where productivity (output) exceeds the constraint level Q, total cost could be reduced by way of reduced last-term pay, in turn removing some fifth-termers from the system. This does have feedback through the perceived pay calculation on earlier rentention rates, but any such deterrent effect on earlier retention or reduced retention in the last term is not great enough to make the case for exceeding the productivity constraint. If this preliminary conclusion, based on empirical computer runs, is true, the nonlinear programming algorithms for the classical approach will be greatly simplified.

While the results of the first application of dynamic programming to solving the dynamic decision problem are uninspiring, the approach is possibly the only feasible one. All the problems discussed were expected and each has ameliorating measures, even if they can at times be costly. The advantages of dynamic programming are almost as numerous as the problems and perhaps have not been treated as fully. One such advantage that is particularly important in manpower planning is the general functional relationships allowed. They can be entered in tabular rather than analytic form, and thus the retention behavior and productivity functions can be completely arbitrary.

CONCLUSIONS

The importance of dynamic manpower policy in the efficient use of military manpower has become increasingly evident during the course of this research. In spite of their importance, a proper decisionmaking framework or helpful models have not yet been developed to assist decisionmakers during the transient period. In fact, the development and use of steady-state models, both those using explicit optimization and those using policy simulation, has led to a static steady-state mentality. The steady-state objective force structure has become the planning objective, and getting to it and staying there the operating policy in the immediate term.

Because of uncertainties in statistical data and in projecting future requirements, technology, and socioeconomic conditions, and because of the effect of discounting, the shorter-term decisions should receive increased attention. *Where* should now take a back seat to *how* the military force is headed. Steady-state analysis is needed as input to the dynamic planning process. Planning consists of knowing where we are headed first and then how to get there. The optimal manpower policy will always be changing because of changing inputs, requirements, etc. To base manpower policy on a static long-term steady-state model is simply poor management and is an inappropriate use of the steady-state model.

This research conducted here has examined one of several methods of finding the dynamic manpower policy. The problems encountered may be surmountable, and other approaches hold promise as well. Models developed as decision aids during transient conditions can be solved and should play an increasingly important role in military manpower planning.

The philosophy of optimal dynamic manpower mixes must be given more serious attention. The rigid requirements, grade limitations, promotion patterns, and year-group limitations that typify today's military manpower planning are not optimal. The civilian labor force in the free market system does not operate under a similar rigidity. This paper has demonstrated that a planning tool is available to provide the general guidance necessary to change the rigid system and improve the efficiency of the military manpower system.

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Part II

MANPOWER PROCUREMENT

THE SUPPLY OF ENLISTED VOLUNTEERS IN THE POST-DRAFT ENVIRONMENT: AN EVALUATION BASED ON PRE-1972 EXPERIENCE[1]

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This study extends a sample of quarterly time-series observations from 1968 (where the Gates Commission studies ended) to 1972 and refits and reevaluates the parameters of the Army enlistment supply equation. Estimated pay elasticities average 1.15, slightly below the 1.25 used by the Gates Commission. Estimated employment rate elasticities are not very robust and are not estimated with a great deal of precision, averaging 1.12 in the "best" models, also slightly below the 1.25 implicit in the Gates Commission recommendations.

The models tend to systematically overpredict the number of Army enlistments in 1973 and 1974, possibly reflecting (1) failure to account for the reduction in risk associated with the move to the lottery draft in 1970, (2) failure to account for a downward trend in the pay elasticity as the sample is extended outward from 1958, or (3) underestimation of the enlistment impact of the draft.

INTRODUCTION AND SUMMARY

In assessing the feasibility of an all-volunteer force, the Gates Commission concluded that pay increases to first-term enlistees aimed at eliminating the conscription tax would also be sufficient to eliminate the draft. This conclusion was based in part on extensive econometric

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analyses of enlistment and reenlistment supply behavior. These analyses produced an estimated military pay elasticity of 1.25 and an assumed employment rate elasticity of the same magnitude for enlistees (Gilman, 1970). Many of the Gates Commission recommendations have been implemented, and the draft was eliminated as a source of manpower procurement in 1973. Experience since that time suggests that the estimates of the Gates Commission have held up rather well. However, the unusually high unemployment rates experienced in 1973-1974 may have contributed to this apparently successful transition. Moreover, these estimated elasticities were generated from data that reflected the existence of the draft and an unpopular war in Southeast Asia. It is possible that the shift from the draft to a no-draft environment and the shift from an environment of hostility to one of peace could have combined to produce significant changes in the parameters of the enlistment supply function. If so, then it is further possible that these changes will have important implications for assessing the future sustainability of an all-volunteer armed force.

The objective of this study is to evaluate the validity of the Gates Commission estimates of military pay and unemployment rate elasticities for use in developing future policies to sustain the all-volunteer armed force. Since little systematic econometric modeling of enlistment supply behavior has been done since the Gates Commission study, this paper constitutes an update of those findings.

Most enlistment studies have been able to identify a significant relationship between military pay and enlistments but have been unable to identify a statistically significant relationship between unemployment rates and enlistments (Fechter, n.d.). The failure to develop robust and efficient estimates of the independent effect of unemployment on enlistments constrained the Gates Commission to the implicit assumption that the effect on enlistments of a 1 percent change in the probability of employment would be equivalent to the effect on enlistments of a 1 percent change in expected civilian pay rates. Much of the effort in this study is directed at developing a more direct and reliable estimate of the effect of unemployment on enlistment behavior than the one used by the Gates Commission. Moreover, since the Army is expected to have the most serious problem in sustaining an

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all-volunteer armed force, the effort is further concentrated on evaluating alternative enlistment models for the Army.

The research consists of estimation of the parameters of enlistment models using quarterly data for the sample period 1958-1972 and generation of projected quarterly enlistments from these parameters for calendar years 1973-1974. The analysis constitutes an evaluation of the stability of the Gates Commission estimates in two ways: (1) by estimating the parameters of the enlistment supply function over a longer time period (the Gates Commission estimates were generated from a data base that ended in 1967 or 1968), and (2) by using these parameters to generate predicted enlistments in the post-draft, post-Vietnam era to compare with actual enlistment experience. The forecasting analysis is an indirect test of the stability of the enlistment supply parameters estimated using quarterly time series data updated through 1972. Systematic forecasting errors would suggest that these parameters are changing in the post-draft environment.

The "best" models produced military pay elasticities ranging between 0.8 and 1.5. The modal elasticity ranged between 1.1 and 1.2 and the average was 1.15, somewhat lower than the Gates Commission estimate of 1.25. Moreover, as shown in related, but as yet unpublished research, pay elasticity tends to decline over time (Fechter, n.d.). This decline may simply reflect the influence of the Vietnam War, and with cessation of hostilities, the elasticity may begin to rise again. However, should the decline prove to be more permanent, it will have important implications for military manpower policy. Among these implications will be (1) more serious consideration of recruiting variables other than pay and allowances, (2) consideration of further increases in relative military pay to maintain a given target level of accessions, and (3) the possibility of a declining trend in the future number of non-prior-service accessions if no further action is taken.

Findings on the effects of employment conditions were disappointing. Few of the models produced employment rate parameters that had the theoretically expected sign and were statistically significant. However, among the better models, the estimated elasticity of enlistments with respect to employment rates generally exceeded unity (in absolute terms) and also exceeded the elasticity of enlistments with respect to military pay. The elasticity averaged over the "best" models was 1.12, slightly lower than that implied by the Gates Commission.

Employment rate elasticities of 1.0 to 1.5 imply that a 1 percent increase (decrease) in the rate of teen-age male unemployment—assuming a current rate of 15 percent—will produce an increase (decrease) of about .012 to .017 percent in the rate of Army enlistments in Mental Categories I-III. Translated into actual numbers, a 1 percent increase (decrease) in the rate of teen-age male unemployment will result in an increase (decrease) in the annual number of enlistments of from 1,700 to 2,700. Given the current unusually high rates of unemployment, the Army can expect a less favorable recruiting climate as teen-age unemployment rates decline to more normal levels. This will mean a decline in the expected number of future accessions as civilian labor markets tighten. A return to 1966-1967 rates of unemployment, for example, could reduce the number of Army enlistments by from 8,500 to 13,500 below the 1972 level of 116,000.

To summarize, the Gates Commission estimates of pay and employment rate elasticities do not appear to change much when the sample period is extended from 1968 to 1972. However, the evidence on the employment rate effect is quite weak—the elasticity estimates are not very robust or precise. Moreover, the slight decline in the military pay elasticity may be indicative of longer-term trends. Thus, it would be desirable to monitor these elasticities using more recent enlistment experience to see whether this downward trend is continuing and to derive more robust estimates of the employment rate elasticity.

Details of the research methods and findings of this study are described below.

RESEARCH METHODS AND FINDINGS

A quarterly time series data base extending from the first quarter of calendar year 1958 (1:58) through the second quarter of 1974 (2:74) was constructed to evaluate the performance of alternative combinations of model assumptions, estimates of variables, and periods of analysis. Supply parameters for Army enlistees in Mental Categories I-III were generated from quarterly data for the period 2:58 to 4:72. The analysis was limited to Army enlistees in these mental categories because they were most likely to be supply-determined (since the Army had to resort to conscription during this period). The estimating equation used was a logit function:

$$\ln\left(\frac{e_t}{1 - e_t}\right) = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_{it} + \nu_t ,$$

where e_t is the enlistment rate in quarter t, X_t is the value of independent variable X in quarter t, and ν_t is the error term (assumed to have the usual stochastic properties).

The supply parameters were used to generate estimates of predicted enlistments for the period 1:73 to 2:74, six quarters. These predicted enlistments were then compared to actual enlistments for those six quarters to assess the forecasting accuracy of enlistment supply models whose parameters were estimated from data that reflect the existence of conscription and a war in Southeast Asia.

Models Tested

The basic model assumes that enlistments are a function of military pay (M), civilian pay (C), the probability of being drafted (DP), the probability of employment for those who do not enlist (EMP), an index of the actual conflict in Southeast Asia (CAS), an index of international tension (BERLIN), and seasonal variables (SII, SIII, and SIV). This is the model used by Fechter (1972), and these variables are estimated using exactly the same techniques. Eight variants of this basic model are explored to examine the effects of alternative ways of specifying the pay variables, alternative assumptions about the speed of adjustment to changes in enlistment determinants, and alternative assumptions about the seasonal determinants of enlistments.

Alternative ways of specifying the pay variables are attempted to evaluate the assumption of symmetry in enlistment response to given changes in M and C. Earlier studies questioned the validity of this assumption, which is implicit in most enlistment models (Fechter, 1972). To test the symmetry assumption, alternative equations are estimated: One set of equations relates enlistment rates to changes in relative military pay (M/C); another set of equations relates enlistments to real values of M and C. The former equations are called the "relative pay models." The relative pay models are based on the assumption of symmetry of enlistment response to pay changes; the absolute pay models are not constrained to this assumption.[2]

Alternative assumptions about the speed of supply adjustment include (1) adjustment to changes in enlistment determinants occurs within one period, and (2) adjustment to these changes takes more than one period. Most enlistment models have assumed that adjustment occurs within one period. To test the alternative assumptions about the speed of adjustment, two sets of equations are estimated: One includes the enlistment rate lagged one quarter as an independent enlistment determinant; the other does not include this variable. The former equations are called the "dynamic models," and the latter equations are called the "static models."[3]

Alternative assumptions about seasonal determinants of enlist-

[2] Fechter (1972), Appendix C, discusses this issue in some detail.

[3] See Fechter (1972), pp. 6-7, n., for a detailed discussion of these models.

ment include the following: (1) there is a stable seasonal pattern in enlistment behavior that cannot be explained by any of the other variables included in the enlistment function, and (2) the seasonal pattern in enlistment simply reflects the seasonal pattern of the variables of the enlistment function. Most of the earlier time series models adopt the first assumption, although Klotz (1970) experimented with the second assumption. To test these seasonality assumptions, alternative sets of equations are estimated: One set includes the standard quarterly dummy variables, and the other totally excludes seasonal variables. The first set of equations is called the "seasonal models," and the second is called the "no-seasonal models."

The estimating equations are summarized below and classified by equation numbers:

Equation No.	*Model*
1RS	Static, relative pay, seasonal
1R	Static, relative pay, no-seasonal
2RS	Dynamic, relative pay, seasonal
2R	Dynamic, relative pay, no-seasonal
1AS	Static, absolute pay, seasonal
1A	Static, absolute pay, no-seasonal
2AS	Dynamic, absolute pay, seasonal
2A	Dynamic, absolute pay, no-seasonal

In addition to the basic model, hereafter referred to as Model I, several other models were tested. Fisher (1969), Klotz (1970), and Kim et al. (1971) use values of EMP that are lagged one quarter in their estimating equations to minimize the adverse effects of simultaneous-equations bias.[4] Model II replicates this experiment; in addition, it lags DP and CAS one quarter.

Model III is an experiment on an alternative expectations hypothesis. It can be argued that enlistment decisions are made on the basis of expectations extending over the period of the enlistment contract. In the Army, this is usually a three-year period. It can also be argued that for variables that display highly volatile behavior (such as DP and EMP), current values or values that are lagged one quarter are poor approximations of these expectations. Model III uses an adaptive expectations hypothesis to estimate DP and EMP. This hypothesis assumes that future expectations are adjusted according to past error in expectations. Given these assumptions, EMP and DP can be ex-

[4] They also lag their estimate of relative pay one quarter.

pressed as weighted averages of their lagged values, where the weights decline as the lag increases.[5]

The results of these models and model variants are summarized below. Particular findings reported include (1) estimates of military pay elasticities, (2) estimates of employment rate elasticities, (3) estimates of forecasting performance based on 1973-1974 experience, and (4) a ranking of the "best" models (based on their forecasting performance).

Pay Elasticities

Table 1 summarizes estimates of military pay elasticities generated by these studies.[6] Military pay elasticities are estimated from regression coefficients that are statistically significant in nineteen of the twenty-four cases summarized. The elasticities range in value from 0.64 to 1.50. They are higher in the absolute pay models than in the relative pay models. Moreover, although not summarized here, the elasticities of the civilian pay variables in these models are consistently at least one-third higher (in absolute value) than the elasticities of the military pay variables.

Employment Rate Elasticities

Table 2 summarizes the estimates of the employment rate elasticities generated by the models tested. Marginally significant coefficients are generated by only six equations.[7] Eleven of the 24 equations produced coefficients of EMP that had the "wrong" sign (i.e., positive coefficients). The range of employment rate elasticities estimated from

[5] The estimating equation for these variables is:

$$X_t^* = \sum_{i=1}^{n} \beta(1-\beta)^{i-1} X_{t-i} / \sum_{i=1}^{n} (1-\beta)^{i-1}$$

where X^*_t is the actual value of X in period t, X_{t-i} is the actual value of X in quarter $t-i$, β is the coefficient of expectations, assumed to be 0.5, and $n = 6$. For a detailed discussion of these expectations models, see Nerlove (1958), pp. 227-240.

[6] The elasticity of an independent variable in a logit estimating equation is: $b_x(1-e)X$, where b_x is the estimated regression coefficient of X, $1-e$ is the complement of the enlistment rate, and X is the value of the independent variable. In this paper, elasticities are estimated at 1972 values of e and X, and e is equal to 0.005161. In the relative pay models, X is equal to 1.01, and in the absolute pay models, X is equal to $7,333.

[7] Marginal significance is defined as a t-value greater (in absolute terms) than 1.3. None of the coefficients had t-values greater than 2.0. Elasticities are computed at the 1972 value of EMP, .8314.

Table 1

SUMMARY OF MILITARY PAY ELASTICITIES,
ARMY ENLISTMENTS, MENTAL CATEGORIES I-III,
1958-1972

	Model		
Equation Number	No Lag I	One Quarter Lag II	Adaptive Expectations III
1RS	.88	.72	.72
1R	.88	.64	.77
2RS	1.47	.85[a]	.75[a]
2R	.92	.64[a]	.69[a]
1AS	1.06	.93	1.14
1A	1.07	.84	1.12
2AS	1.40	.98	1.09[a]
2A	1.20[b]	1.04[b]	1.50[b]

[a] t-statistic < |2.0|.

[b] Assumes instantaneous adjustment because the coefficient of the lagged endogenous variable had the "wrong" sign.

Table 2

SUMMARY OF EMPLOYMENT RATE ELASTICITIES,
ARMY ENLISTMENTS, MENTAL CATEGORIES I-III,
1958-1972

	Model		
Equation Number	No Lag I	One Quarter Lag II	Adaptive Expectations III
1RS	(a)	-.06[b]	-.01[b]
1R	(a)	-1.41	-2.57
2RS	(a)	-1.54[b]	-.15[b]
2R	(a)	-1.52[c]	-2.59
1AS	(a)	(a)	(a)
1A	(a)	-.90[b]	-2.08
2AS	(a)	-.30[b]	(a)
2A	(a)	-.34[b,c]	-1.50[c]

[a] The regression coefficient has the "wrong" sign.

[b] t-statistic < |1.3|.

[c] Assumes instantaneous adjustment because the coefficient of the lagged endogenous variable had the "wrong" sign.

those coefficients that had the "right" sign was −0.01 to −2.6. The range estimated from coefficients that were found to be marginally significant was −1.4 to −2.6. Models that account for simultaneity by lagging EMP one quarter (Model II) and that formulate a long-run expectation of EMP using the adaptive expectations hypothesis (Model III) perform better than the alternative models. However, even these models do not produce reliable results. The best results are generated by Model III, which produces three marginally significant coefficients out of the eight equations reported.

We can only speculate about the reasons for the poor performance summarized in Table 2, but an important possibility would be simultaneous-equations bias arising from using ordinary least-squares techniques to estimate the coefficient. Analysis of the intrayear variation in EMP reveals a seasonal high in the third quarter, when enlistments also tend to be high. It also reveals that EMP rose dramatically in 1965-1966 and remained at higher levels thereafter. This interyear increase in EMP coincides with higher enlistment levels that accompanied U.S. involvement in Southeast Asia. This evidence suggests that causality may have run from enlistments to EMP (i.e., that EMP was an endogenous variable) during this period. Use of lags and adaptive expectations seems to reduce the problem of simultaneity arising from intrayear variation in EMP; however, the problem arising from interyear variation still remains.

Picking the "Best" Model

Selecting the "best" results for policy purposes is a difficult task—largely because it is an arbitrary decision. There are many factors that can be considered in making the selection: the conformity of the results to theoretical expectations, the goodness of fit of the estimating equation, the forecasting accuracy of the estimating equation, etc. The factor considered in this study was the forecasting accuracy of the estimating equation. Table 3 summarizes the forecasting accuracy of the equations for the six quarters beginning with 1:73 and ending with 2:74. Two measures of accuracy are displayed: the root mean square error and the mean error. The latter measure is signed, thus enabling us to determine whether the average forecast overestimates (a negative mean) or underestimates (a positive mean) the average actual experience.

The findings from this table may be summarized as follows. The models tend to consistently overpredict enlistment, but not by much. Twelve equations have mean errors of less than 10 percent, and 13 equations have root mean square errors of less than 20 percent. (The average quarterly enlistments for this period were 31,000.) However,

Table 3

SUMMARY OF FORECASTING PERFORMANCE OF MODELS (MEASURED IN TERMS OF ROOT MEAN SQUARE ERROR AND MEAN ERROR (IN PARENTHESES)), ARMY ENLISTMENTS, MENTAL CATEGORIES I-III, 1:73–2:74
(In thousands of enlistments)

Equation Number	Model: No Lag I	One Quarter Lag II	Adaptive Expectations III
1RS	9.6	7.7	6.9
	(-8.2)	(-5.9)	(-4.6)
1R	10.6	6.3	5.3
	(-9.6)	(-4.4)	(-1.9)
2RS	6.3	6.2	6.6
	(-2.5)	(-2.3)	(-2.7)
2R	10.3	6.0	5.3
	(-9.2)	(-4.0)	(-1.9)
1AS	6.6	5.4	4.8
	(-5.1)	(-3.4)	(-2.5)
1A	7.5	4.5	4.2
	(-6.3)	(-2.1)	(+0.1)
2AS	5.7	5.3	5.5
	(-2.6)	(-2.1)	(-2.2)
2A	8.7	5.0	4.0
	(-7.6)	(-3.3)	(-0.8)

these measures of performance are biased by inclusion of 2:73, a quarter in which the Army arbitrarily raised enlistment standards, producing an unusually low level of enlistments. If this quarter were excluded from the measures, the results would be even better.

The tendency to overprediction could be explained by a number of alternative hypotheses. For example, it might be hypothesized that the systematic overestimation is caused by failure to deal with the effects of draft uncertainty. Before 1970, draftees were selected on the basis of age, with the oldest eligible inductees drafted first. This method of selection introduced a considerable amount of uncertainty into the lives of potential inductees who were within the age range of possible call. Moreover, the likelihood of being inducted, given eligibility to be drafted, rose with age. Therefore, many potential inductees had incentives to enlist to control the timing of their military service. After 1970, the method of induction changed to a lottery in which part of the pool of 19 year olds was selected. Older age groups were vulnerable only when the pool of 19 year olds was exhausted. The lottery method of selecting inductees substantially reduced the uncertainty associated with the older method and should have had the effect of reducing enlistments that were motivated earlier by the existence of this uncertainty. The models described in this paper fail to account for this effect and may overstate enlistments because of this failure. In an earlier study, annual Army enlistments were estimated at anywhere from 26,000 to 43,000 lower because of the reduction in uncertainty associated with the lottery.[8] The annual overpredictions implied by the figures in Table 3 are well within or below this range.

Another possible reason for the overprediction of enlistments is that the models do not fully capture a secular tendency for the relative pay elasticity to decline. The elimination of the draft at the end of 1972 followed by one year a substantial military pay increase that went into effect in late 1971. The pay elasticity estimated by the models assumes no trend in its value. In a related, but as yet unpublished research study (Fechter, n.d.), a consistent tendency is found for the pay elasticity to decline as the sample period is extended from 1958 to later and later periods. Part of the reason for this trend appears to relate to the Vietnam War. Pay elasticities during the period of this conflict were highly inelastic, reflecting the apparent redistribution among potential enlistees taken for military service as the war became more and more unpopular. Failure to account for this trend in these models may have resulted in overestimation of the enlistment effect of the large pay change that occurred in 1971. While part of this error should have been corrected by 1972 enlistment experience, it is possible that the four quarters of observation in 1972 were not sufficient to compensate for the bias generated by the earlier 56 observations.

Still other reasons, including possible underestimation of the impact of the draft and structural changes in the post-draft parameters of the enlistment function, can be put forth to explain the overestimation of post-draft Army enlistments. Further analysis would be required to provide a deeper understanding of the aspects of these models that result in forecasts of too many enlistments. However, the systematic nature of the error should be a warning against relying too heavily on the parameters generated by earlier enlistment experience. Prudence dictates continual monitoring of these parameters, using more recent enlistment experience.

Model III generally produces the most accurate forecasts. Absolute pay models tend to produce more accurate forecasts than relative pay models. And, within Model III, the no-seasonal models tend to produce more accurate forecasts.

[8] See Fechter (1972), pp. 25-27.

Table 4 summarizes the military pay and employment rate elasticities generated by the equations that produced the most accurate forecasts (in terms of their root mean square error of forecast). Four equations produced root mean square errors of less than 5,000. Only one of these equations produced a pay elasticity of less than 1.0. Two produced pay elasticities that ranged between 1.1 and 1.2, which is the modal range of the pay elasticities. Three of the four equations produced employment rate elasticities that had the "right" sign. The elasticities ranged in value from −.9 to −2.8. Two of these three elasticities were generated from coefficients of EMP that were marginally significant.

Table 4

RANKING OF "BEST" MODELS, BASED ON ROOT MEAN SQUARE ERROR

			Elasticity with Respect to:	
Model	Equation	Root Mean Square Error	Military Pay	Employment Rate
III	2A	4.0	1.50[a]	-1.50[a]
III	1A	4.2	1.12	-2.08
II	1A	4.5	.84	- .90[b]
III	1AS	4.8	1.14	(c)

[a]Instantaneous adjustment is assumed, since the regression coefficient of the lagged endogenous variable had the "wrong" sign.

[b]t-statistic < |1.3|.

[c]The regression coefficient of the employment rate had the "wrong" sign.

CONCLUSIONS

Efforts to assess the stability of the pay and employment rate elasticities used by the Gates Commission in recommending pay increases required to move to an all-volunteer force have been described in this paper. One part of the analysis consisted of extending the sample of quarterly time series observations from 1968 (when the Gates Commission studies ended) to 1972 and refitting the parameters of the Army enlistment supply equation. Another part consisted of using those parameters to predict 1973 and 1974 enlistment experience and comparing the predicted experience with the actual experience.

Estimated pay elasticities averaged 1.15, slightly below the 1.25 used by the Gates Commission. Estimated employment rate elasticities frequently had the "wrong" sign, and those with the "right" sign were not very robust and were not estimated with a great deal of precision. The employment rate elasticity estimated from the "best" models averaged 1.12, also slightly below the 1.25 implicit in the Gates Commission recommendations.

The models tended to systematically overpredict the number of Army enlistments in 1973 and 1974. Possible reasons for this finding included (1) failure to account for the reduction in risk associated with the move to the lottery draft in 1970, (2) failure to account for a downward trend in the pay elasticity as the sample is extended outward from 1958, and (3) underestimation of the enlistment impact of the draft. It was concluded that the systematic tendency to overstate enlistment experience constituted a warning not to rely heavily on enlistment parameters based on past experience in formulating recruiting policy. Continual monitoring of the enlistment parameters based on more recent enlistment experience is recommended. It is also suggested that a continuation of the secular decline in pay elasticities would have important consequences for recruiting policy planning. These consequences further underscore the need to continue monitoring the estimated parameters of the enlistment supply function, using more recent enlistment experience.

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THE SUPPLY OF ENLISTED VOLUNTEERS IN THE POST-DRAFT ENVIRONMENT: AN ANALYSIS BASED ON MONTHLY DATA, 1970-1975[1]

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An enlistment supply model is developed and fit by ordinary least squares to monthly 1970-1975 data. The independent variables are the ratio of military to civilian pay, the youth unemployment rate, and seasonals. The dependent variable is the ratio of enlistments in different quality groups to the 17 to 21 year old population. Regression equations are developed for high-school graduate Category I-II and Category III and non-high-school graduate Category I-II enlistment groups for each service. For high quality Army groups, models are developed for black and white enlistment groups.

The results show both pay and unemployment to be significant determinants of enlistment supply for each service. Pay elasticities vary by service, mental group, and education between .5 and 1.7. Unemployment elasticities are positive for higher quality groups and vary between .25 and 1.25. For lower quality groups, the signs are negative, showing a substitution effect of high quality enlistees for lower quality in times of high unemployment. Pay elasticity for black enlistees was significantly higher than for white enlistees. By developing separate equations by mental group and education, supply and demand limitation can be inferred for different groups. For the Army, demand limitation was present for periods for the Category I-II non-high-school group, while for the Air Force, demand limitation was present for the Category III high-school graduate group. The sensitivity of the results was tested for differ-

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ent pay discount rates and for different lag structures. The pay variable was found not to be sensitive to lag, but to be somewhat sensitive to discount rates. The value of the unemployment elasticity was sensitive to lag.

INTRODUCTION

In looking at the future of the all-volunteer force, most analysts now point to the 1980-1990 time period as being potentially troublesome. These analysts view the present success of the all-volunteer force in achieving the desired quality and quantity of recruits as being partially attributable to high unemployment rates and the favorable population bulge of 17 to 21 year olds.

Population projections show that the peak resulting from the baby boom will occur in 1978, when there will be an estimated 10.8 million males aged 17 to 21. They also show that this population will not dip below present levels until 1983; however, it will decline from 10.8 million in 1978 to 9.2 million in 1987. This is a 15 percent decline in the prime enlistable male population from the 1978 level and a 12 percent decline from 1975 levels. The trend past 1987, based on the 1983-1987 data, indicates a further decline of around 2.5 percent annually.

Unemployment rates for 16 to 21 year old males who are not in school are currently about 18 percent. Average levels for the prerecession period of 1970-1972 were around 13 percent. High unemployment rates, it is believed, lead to high enlistment rates; if unemployment rates decline, enlistments may also decline.

In projecting future enlistment supply, it is important to understand the effects of economic conditions. Previous models (Fechter and Grissmer, n.d.) have been unable to identify significant unemployment effects but have identified military and civilian pay levels as important determinants of enlistments.

The present analysis of monthly data from 1970 to 1975 shows both pay and unemployment effects to be significant. Our success in measuring both variables is probably attributable to three factors:

1. The enlistment variable included *volunteer* enlistments only and no draft variable was included.
2. The enlistment data were disaggregated so that supply and demand limitations could be determined.
3. Both military pay and civilian unemployment had sudden and large changes.

This study consists of a monthly analysis of volunteer enlistments from 1970 to 1975 for several different educational, mental category, and racial groups for each service. The results of the analysis show that the pay variable is positive and significant at the .01 level for all groups for each service. For DoD enlistees, pay elasticities range from .9 to 1.35, depending on education and mental category level. Military pay elasticities are higher for the Army (1.2 to 1.9) and lower for the Marine Corps (.4 to 1.4). In general, these elasticities are biased upward because of the effects of recruiting and advertising changes that were also occurring in the period. The best estimate of relative pay elasticity for the Mental Category I-III Army enlistee is 1.3 to 1.4. This measurement is in agreement with Gates Commission estimates but differs somewhat from recent work by Fechter (Chap. 1 of this volume), where pay elasticities from relative pay models average .8. Pay elasticities are dramatically higher for black Mental Category I-III high-school graduate enlistees (4.13) than for comparable nonblack enlistees (.94). This suggests that in the absence of constraints, improvement in relative military pay will shift the racial composition of the Army toward more blacks.

The model was successful in identifying an employment rate effect, but only when the data were disaggregated by mental category and level of school completed. Significant elasticities are estimated for DoD enlistees who were high-school graduates at the time they enlisted; these elasticities range between 1.25 and 2.5. Similar results are found for Army enlistees, except that their elasticities tend to cluster closer to 2.5. Marine Corps elasticities are generally considerably higher than Army elasticities, and Air Force elasticities tend to have the "wrong" sign. These elasticities are not particularly sensitive to lag structures, but they are sensitive to inclusion of a variable indexing rationing. The pattern of the unemployment elasticities suggests substitution effects of higher-quality enlistees for lower-quality during periods of high unemployment. The results also show that at present, only upper mental category high-school graduate groups are supply-limited for all services, and upper mental category nongraduates are demand-limited for all services except the Marine Corps.

RESULTS USING A MONTHLY TIME SERIES DATA BASE

Monthly volunteer enlistment data for each service from June 1970 to July 1975 have been analyzed using three different econometric models to determine enlistment supply determinants. Emphasis was placed on determining the influences of military wage level and civilian unemployment level on the enlistment supply of different racial, educational, and mental category volunteer groups. Regression models were run for the volunteer groups shown in Table 1.

Table 1

VOLUNTEER GROUPS ANALYZED FOR MILITARY PAY AND UNEMPLOYMENT INFLUENCES

Volunteer Group	Army	Navy	Air Force	Marine Corps	DoD
Category I, II high-school graduates	X	X	X	X	X
Category III high-school graduates	X	X	X	X	X
Category I, II nongraduates	X	X	X	X	X
Category I-III	X	X	X	X	X
Black Category I-III high-school graduates	X				
Nonblack Category I-III high-school graduates	X				

For purposes of forecasting and derivation of supply determinants, regression analysis using the monthly volunteer enlistment data from June 1970 to July 1975 has both advantages and disadvantages relative to the use of data aggregated into longer time segments or cross-sectionally. Two major advantages are the precise specification of the volunteer supply variable and the dramatic changes in pay and unemployment variables that occurred in this period. An estimate of true volunteers into the armed services can be made precisely only since the start of the lottery system in 1970. Almost all previous analyses have had to include draft variables to account for draft-motivated enlistments. Enlistees with high lottery numbers should be free of draft pressure and can be considered true volunteers. From 1970 to the end of the draft in 1972, no draft calls were issued for lottery numbers higher than 200. For this analysis, an estimate of true volunteers has been made using accessions with lottery numbers greater than 240. The draft ended at the end of 1972; therefore, taking account of delayed entrants, all accessions after June 1973 are true volunteers.

During this period, there was a large pay increase for service accessions. This pay increase, recommended by the Gates Commission to make the volunteer force more feasible, approximately doubled pay for servicemen in pay grades E-1 to E-3 at the end of 1971. Generally, pay increases given to servicemen over the last 15 years have been for "cost of living." Also in this time period, unemployment rose dramatically. In late 1974, the unemployment rate for 16 to 21 year old males increased by about 100 percent. The magnitude and suddenness of these increases in key variables provides an unusual opportunity to measure their elasticities from regression coefficients that are more precise.

Of course, the 60 monthly data points have a strong seasonal component, and thus seasonal dummies are necessary. The 12 seasonal dummies plus pay and unemployment total 14 variables for 60 data points. Since the seasonal dummies account for a large fraction of the R^2 value in each regression, more data would certainly be desirable. Also, other factors that influence enlistments were changing during this period. Particularly troublesome is the increase in recruiting and advertising resources. The number of recruiters in all services increased by 100 percent during this time, and advertising outlays increased by 1000 percent. Unfortunately, the variable measuring recruiting effort is highly collinear with the pay variable, making separation of the two effects impossible with the data used in this analysis. The estimated pay elasticities are probably biased upward and should be interpreted as upper limits of the actual pay elasticities.

Another major problem in determining accurate parameters of enlistment supply is changes in service manpower policies. Quotas for the services vary from one year to the next, and enlistment quality standards also vary. Data for certain volunteer groups, notably non-high-school graduates and Mental Category IV groups, are dominated by service policy—i.e., are demand-limited. Different groups are supply-limited in each service. For instance, the Category I-II non-high-school graduate group has been supply-limited to the Army but demand-limited to the Air Force. We have chosen for analysis groups that generally have not been affected by service restrictions for at least one service during the entire period. The Category I-II high-school group is the preferred group for all services and has been supply-limited for the entire period. The R^2 and the significance of the regression coefficients are expected to decrease as a result of demand limitations. These effects are reflected in our results.

Models

Three basic models were used to test volunteer response to pay and unemployment changes. These models are listed and described below:

1. *Linear model with dummy seasonals (LS1), the military-civilian pay ratio, and the youth unemployment rate as variables:*

$$E_k = \alpha_0 + \sum_{i=1}^{12} \alpha_i \delta_{ik} + \sum_{N=-3}^{+3} (\beta_1 W_{k,2N} + \beta_2 U_{k,2N}) \qquad (k = 1, 60)$$

2. *Multiplicative seasonal model (MS1):*

$$E_k = \prod_{i=1}^{12} e^{\alpha_i \delta_{ik}} \left(\sum_{N-3}^{+3} (\beta_1 W_{k,2N} + \beta_2 U_{k,2N}) + \beta_0 \right)$$

3. *Log-linear model with seasonals (MS2):*

$$E_k = \beta_0 \prod_{i=1}^{12} e^{\alpha_i \delta_{ik}} \prod_{N=-3}^{+3} (W_{k,2N})^{\beta_1} (U_{k,2N})^{\beta_2}$$

where E_k = volunteer rates for month k,
W_k = pay ratio for month k with delay 2N, in months,
U_k = unemployment rate for month k with delay 2N, in months,
α_i, β_i = regression coefficients, and
δ_{ik} = 1 if i = kMOD(12), 0 otherwise.

The models were estimated using ordinary least-squares techniques. Model MS1 is nonlinear and cannot be converted to linear form through transformation. An iterative technique was developed and implemented on the UCLA Biomed package to solve for β_0, β_1, and β_2 and the seasonals. (A description of this technique can be found in Grissmer et al, 1974.) In each model, lagged variables were used for both pay and unemployment. Experiments were made with lags of +6, +4, +2, 0, −2, −4, and −6 months. Lag effects arise both from the delayed entry program (DEP), which allows potential enlistees to sign contracts up to six months before they actually enter service, and from the normal delays between changes in unemployment and pay and enlistments. Because of multicollinearity between lagged variables, one set is used for each model. The results reported here are for the sets of lags that produce the largest reduction in the residual variance in the enlistment rate (after seasonal factors are accounted for).

The dependent variable used in this analysis is the voluntary enlistment rate. For the months before January 1973, the number of voluntary enlistments is inferred from enlistment data classified by lottery. (Details of how voluntary enlistments are generated from these data can be found in Amey et al., 1976.) The denominator is the population of 17 to 21 year old males, projected from census data. Military pay is designed to include base pay, quarters and subsistence allowances, and the tax advantage on these allowances. This pay was estimated as the undiscounted quarterly average summed over the first three years of active military service. Estimates for 1975 were derived by raising basic pay by 5 percent over 1974 levels. Civilian pay is estimated as the pay of year-round, full-time workers 18 through 20 years old. The estimation technique is the same as that used by Fechter (1972). The unemployment rate is estimated from the unemployment rates of 16 to 21 year old males whose major activity was other than going to school. These rates were deseasonalized before they were used in the analysis. (Details of the seasonal adjustment process are found in Fechter and Grissmer).

Table 2 summarizes the results for DoD volunteers. The results are evaluated in terms of the following criteria: (1) significance, signs, and values of the pay and unemployment elasticities; (2) quality of fit of the models; (3) lag structure for pay and unemployment; and (4) consistency of elasticities for different models.

Pay and Unemployment Elasticities for Total DoD Volunteers

Pay elasticities are positive and generated from regression coefficients that are significant at the .01 level for all models and all groups. They range from 0.9 to 1.4 and vary strongly by mental category and level of school completed. There is little variation by model type. Table 3 compares the DoD pay elasticities averaged over all models for each of the three groups. Observed differences in pay elasticities between educational and mental category groups may arise in several ways. For example, they could reflect changes in mental category classification methods over the period; or, they could be due to errors in the measure of civilian pay, which is not broken down by education or mental category. Here, we assume that the classification scheme has remained stable over the period, and our results are consistent with the hypothesis that since potential enlistees in the higher mental category and educational attainment groups have better civilian earnings opportunities, the military pay elasticity computed from models LS1 and MS1 should vary inversely with the average civilian wage open to each group, other things being equal. These results are reported in Table 3.

The unemployment elasticity is positive and significant at the .01 level for the Category I-II high-school graduate group; it is significant at the .05 level for the Category III high-school graduate group and negative and less significant for the Category I-II nongraduate group. It is not statistically significant at all for the Category I-III group. The average unemployment elasticities are shown in Table 4 for the first three groups.

The observed differences in elasticities may be a reflection of measurement errors in our estimated unemployment rates, which are not broken down by mental category or level of school completed. Alternatively, these unemployment elasticities might be explained in terms of rationing effects. For the preferred quality groups (Category I-III high-school graduates), higher unemployment brings additional personnel into the service. As more of these become available, the services accept fewer of the lower-quality enlistees—i.e., Category I-II nongraduates. The negative unemployment elasticity for this group is

Table 2

DoD VOLUNTEER RATES

Model	Pay Ratio Variable			Unemployment Variable			R^2	Durbin-Watson Statistic
	Elasticity	Significance Level[a]	Delay	Elasticity	Significance Level[a]	Delay		
				Category I, II High-School Graduates				
MS1	.892	.01	(−6)	.485	.01	(−2)	.708	1.435
LS1	.906	.01	(−6)	.448	.01	(−2)	.929	1.213
MS2	.883	.01	(−6)	.441	.01	(−2)	.929	1.340
				Category III High-School Graduates				
MS1	1.102	.01	(−6)	.223	.05	(−2)	.618	.930
LS1	1.187	.01	(−6)	.237	.10	(−2)	.891	.883
MS2	1.146	.01	(−6)	.290	.05	(−6)	.908	.841
				Category I, II Nongraduates				
MS1	1.315	.01	(−0)	−.339	.10	(−6)	.521	.775
LS1	1.384	.01	(−0)	−.182	.20	(−0)	593	.739
MS2	1.355	.01	(−0)	−.302	.10	(−6)	.632	.792
				Category I-III Total Volunteers				
MS1	1.010	.01	(−4)	.094	.40	(−6)	.612	.802
LS1	1.016	.01	(−6)	.175	.20	(−6)	.860	.786
MS2	.982	.01	(−6)	.162	.20	(−6)	.849	.778

[a]All significance (confidence) levels are based on the t-statistics for the coefficients of the independent variables.

Table 3

COMPARISON OF DoD PAY ELASTICITIES[a]
FOR FOUR VOLUNTEER GROUPS

Volunteer Group	Pay Elasticity
Category I, II high-school graduates	.89
Category III high-school graduates	1.15
Category I, II nongraduates	1.35
Category I-III	1.00

[a]Averaged over the three seasonal models.

Table 4

COMPARISON OF UNEMPLOYMENT ELASTICITIES[a]
FOR THREE VOLUNTEER GROUPS

Volunteer Group	Average Unemployment Elasticity
Category I, II high-school graduates	.45
Category III high-school graduates	.24
Category I, II nongraduates	-.30

[a]Averaged over the three seasonal models.

consistent with such effects. The strength of these effects will depend on the overall quota for the services. At higher quota levels for the preferred groups, the unemployment elasticity for the other groups might also show positive signs. This may explain why this substitution effect does not show up in the pay elasticities for the groups analyzed. At the time of the major pay raise, quotas were high and no substitution effects appear for the Category I and II nongraduate group. However, during the time that unemployment rates were high, quotas were lower, producing substitution effects for this group.

Lag Structure

The lag for the pay variable was generally six months, indicating that the effect on enlistments of any pay change takes about that long to occur. This can be explained by information diffusion and the mechanics of delayed enlistment pools. Higher mental category groups tend to choose more specialized skills and must wait for a reserved special-school seat before they can enlist. Thus, enlistments can be delayed as much as six months after contract signing. In this study, the enlistment rate using actual enlistments rather than signed contracts was the dependent variable; thus increases in actual enlistments coming from delayed enlistment pools could occur for up to six months.

For unemployment, the lag was generally two months. Again, this could be due to the delayed enlistment pool as well as to the normal time for civilian job searches before entering the military.

Consistency of Elasticities for Different Models

The elasticities for the pay and unemployment variables for the three models generally were of the same magnitude, although the variance in the values between models was generally greater than that expected from the standard error derived from any individual model. The agreement among models was best for the higher-quality groups.

Elasticities by Service

Table 5 summarizes the pay elasticities for all services. (Details are described in Amey et al., 1976.) A pattern emerges of increasing elasticity with decreasing quality class. The exceptions to this are the Navy Category I-II nongraduate group and the Marine Corps Category III high-school graduate group. The Navy Category I-II nongraduate group is probably demand-limited, and thus the pay effect is masked by policy restrictions for this group. The low pay elasticity for the Marine Corps Category III high-school graduate group is puzzling.

The Army generally has the highest elasticities for each volunteer group, followed by the Navy, Air Force, and Marine Corps. These results may reflect differences in the effectiveness of the recruiting effort of each service as well as differences in service preferences of youth in each group. The Army, with the largest recruiting force, also experienced the largest increase in recruiters in the time period—

Table 5

AVERAGE[a] PAY ELASTICITIES FOR THREE VOLUNTEER GROUPS

Volunteer Group	Army	Navy	Air Force	Marine Corps	DoD
Category I, II high-school graduates	1.22	.94	.84	.74	.89
Category III high-school graduates	1.68	1.55	.99	.57	1.15
Category I, II nongraduates	1.96	.50	1.77	1.77	1.42

[a]Averaged over the three seasonal models.

from around 2,000 to 4,800. Also, the advertising budget of the Army tripled in this time period. The Marine Corps, with the smallest recruiting force, has not, until lately, substantially increased its advertising. In principle, the effect of the recruiting resources should have been included in the analysis; however, the recruiting variables were highly correlated with the pay variable, and omitting the recruiting resources could have biased the pay elasticity of each service. Since the Army received the largest addition to recruiting resources, and the Marine Corps the least, a possible conjecture for the difference in wage elasticity is the absence of recruiting variables from the estimating equations.

Another explanation is simply that people's "tastes" for the nonpecuniary aspects of service differ. For instance, persons entering the Marine Corps typically strongly identify with the image of that service as a "builder of men," while Army enlistees may give relatively more weight to monetary rewards.

Table 6 summarizes the unemployment elasticities for the services. (Details are found in Amey et al., 1976.) The trend for each service is the same as for the DoD, with lower-quality groups having lower elasticities. The most significant unemployment elasticities are in the Category I-II high-school graduate group. In this group, the elasticities are highest for the Air Force and Marine Corps. Substitution effects appear for Category III high-school graduate groups for the Air Force, but only for Category I-II nongraduates for the other services.

Table 6

UNEMPLOYMENT ELASTICITIES[a] FOR THREE VOLUNTEER GROUPS

Volunteer Group	Army	Navy	Air Force	Marine Corps	DoD
Category I, II high-school graduates	.42	.50	.95	1.25	.46
Category III high-school graduates	.37	.35	−.24	.62	.25
Category I, II nongraduates	−.05	−.45	−.84	−.33	−.27

[a]Averaged over the three seasonal models.

Elasticities by Race

An analysis of Army enlistees by race, mental category, and level of school completed was undertaken to determine the differential effects of pay and unemployment. Table 7 summarizes the results, which show positive and significant pay elasticities for both racial groups for a marked difference in the size of these elasticities. (Details

Table 7

PAY AND UNEMPLOYMENT ELASTICITIES, BLACK AND NONBLACK ARMY ENLISTEES

Model	Relative Pay Elasticity	Unemployment Rate Elasticity	R^2	Durbin-Watson Statistic	Relative Pay Lag	Unemployment Rate Lag
		Black Category I-III High-School Graduates				
MS1	3.677	−.624	.704	.770	(−6)	(−2)
LS1	3.863	−.611	.761	.880	(−6)	(−6)
MS2	4.850	−.313	.815	.583	(−6)	(−6)
		Nonblack Category I-III High-School Graduates				
MS1	.907	.460	.425	1.839	(−6)	(−2)
LS1	1.035	.496	.914	1.443	(−6)	(−2)
MS2	.885	.412	.801	1.797	(−6)	(−2)

are given in Amey et al., 1976.) The unemployment elasticities are positive and very significant for nonblack volunteers but negative and less significant for black volunteers. The unemployment elasticities for blacks have the "wrong" sign for black Category I-III high-school graduate enlistments.

Sensitivity Analysis

The sensitivity of relative pay and unemployment elasticities to changes in variable specifications, lags, and inclusion of policy variables is explored below.

Regressions were made on volunteer enlistment rates for DoD and Army groups in which no independent variable lags were allowed to enter a regression equation. These runs were made to estimate the sensitivity of the elasticity measurements found in previous runs where lags of up to six months were predominant in the equations. The results, presented in Table 8, show that small changes in the relative pay elasticities can be expected when no lag is allowed in the relative pay variable. The largest change for DoD volunteer groups was for the Category I-II high-school graduate group, where the elasticity changes from .89 to .79. A significant reduction in the elasticity measurement for the unemployment rate can be expected for DoD Category I-III high-school graduates. DoD Category I-III total group unemployment elasticity is measured as −.037 in one regression, but the coefficient for no variable lag in unemployment is not significantly different from zero.

Another experiment was performed using a dummy variable to represent an Army policy of restricting monthly quotas to 70 percent high-school graduates from February 1973 to July 1973. This policy

Table 8

COMPARISON OF DoD PAY AND UNEMPLOYMENT ELASTICITIES WITH AND WITHOUT LAGS

Volunteer Group	Pay Elasticity		Unemployment Elasticity	
	No Lag	Lag	No Lag	Lag
Category I, II high-school graduates	.79	.89 (-6)	.30	.46 (-2)
Category III high-school graduates	1.19	1.14 (-6)	.10	.25 (-2)
Category I, II nongraduates	1.37	1.36 (-0)	-.15	-.27 (-6)
Category I-III	1.02	1.00 (-6)	-.01	.14 (-6)

was represented as a dummy variable in regressions on Army and DoD volunteer rates. It began immediately in February 1973 (value = 1) and was gradually withdrawn beginning in July 1973 and ending in October 1973 (values = .75, .50, .25, and 0.0).

Results from these regressions indicate a significant negative enlistment response to the policy variable for Category I-III total and Category I-II nongraduate volunteer rates. However, there is no significant positive response to the variable for high-school graduates.

Nongraduate Army enlistees in the Category I-III group were significantly affected by the policy limiting accessions of high-school graduates. We estimate that the Army lost about 980 volunteers per month during the period when this policy was in effect.

Table 9 compares the pay and unemployment elasticities with and without the dummy variables. Pay elasticities for DoD groups are unaffected by the inclusion of the variable; however, Army pay elasticities for the Category I-III and Category I-II nongraduate groups are biased downward significantly by not including the variable. The estimate for the Army Category I-III group of 1.54 is biased upward because of the missing recruiter variable. Estimates of recruiter effects from cross-sectional estimates can be used to set upper limits on the pay bias. Using these recruiting elasticities would reduce the pay elasticity to around 1.3 to 1.4. This estimate agrees closely with Gates Commission estimates but differs somewhat from the estimates of relative pay elasticities of .8 derived in Chap. 1. Unemployment elasticities are significantly affected by the inclusion of the dummy variable: They become *more significant* and negative for the Category I-II nongraduate group. This dramatic shift illustrates the effect that demand constraints can have on elasticities for different groups.

Sensitivity of pay and unemployment elasticities to changes in the definition of pay variables was also investigated. Army volunteer rates for different mental category groups were regressed on pay

Table 9

COMPARISON OF PAY AND UNEMPLOYMENT ELASTICITIES WITH AND WITHOUT DUMMY POLICY VARIABLES

Volunteer Group	Pay Elasticity With	Pay Elasticity Without	Unemployment Elasticity With	Unemployment Elasticity Without
DoD				
Category I-III	1.03	1.00	-.15	-.22
Category I, II nongraduates	1.36	1.35	-.59	-.83
Army				
Category I-III	1.54	1.39	-.22	.24
Category I, II nongraduates	2.04	1.96	-.83	-.05

variables of absolute military and civilian pay and the deseasonalized unemployment rate variable. The results are shown in Table 10.

The pay variables were formed by Fechter's (1972) discounting method, where enlistments are assumed to occur at age 19 and discounting is done over the first three years of service. Each pay variable was then deflated by the CPI.

The results obtained were consistent with previous findings. Pay elasticities are 10 to 12 percent smaller for most volunteer groups. Unemployment variable elasticities are generally the same in this set of regressions; however, the significance levels vary inversely with those of civilian pay. Civilian pay elasticities exceed military pay elasticities by notable margins in all experiments except high-school graduates in Mental Category I-II. The civilian pay elasticity for all Mental Category I-III enlistees exceeds (in absolute value) the military pay elasticity by about 50 percent.

Finally, the sensitivity of pay and unemployment elasticities to discounting methods was tested. Fechter's method of pay discounting at 30 percent for both military and civilian wages is compared with no discounting in Table 11. The pay variable used is the ratio of military and civilian pay, with each discounted at either 30 percent or 0 percent.

The results show that pay elasticity is affected by discount methods. Pay elasticities fall by about 0.2 as discount rates rise from 0 to 30 percent. Unemployment elasticities are, not surprisingly, unaffected by the pay discount rate.

Table 10

Regressions on Army Volunteer Rates, With Absolute Pay Variables

Model	Military Pay			Civilian Pay			Unemployment Rate				
	Elasticity	Significance Level[a]	Delay	Elasticity	Significance Level[a]	Delay	Elasticity	Significance Level	Delay	R^2	Durbin-Watson Statistic
				Category I, II High-School Graduates							
MS1	1.089	.01	(−6)	−.829	.20	(−6)	.479	.01	(−2)	.522	1 87
LS1	1.199	.01	(−6)	−.479	(a)	(−6)	.613	.01	(−2)	.903	1.42
MS2	1.054	.01	(−6)	−.914	.20	(−6)	.380	.10	(−2)	.884	1.74
				Category III High-School Graduates							
MS1	1.389	.01	(−6)	−2.16	.01	(−4)	.189	.40	(−2)	.532	1.541
LS1	1.634	.01	(−6)	−1.168	.20	(−6)	.542	.05	(−2)	.873	1.044
MS2	1.349	.01	(−6)	−2.374	.01	(−6)				.867	1.374
				Category I, II Nongraduates							
MS1	1.629	.01	(−0)	−2.591	.05	(−0)	−.304	.40	(−0)	.252	.672
LS1	1.774	.01	(−0)	−2.301	.10	(−0)	−.388	.30	(−0)	.423	.721
MS2	1.512	.01	(−0)	−2.902	.05	(−0)	−.361	.40	(−0)	.392	.609
				Category I-III Total							
MS1	1.261	.01	(−6)	−1.921	.01	(−0)	.241	.30	(−6)	.455	1.16
LS1	1.363	.01	(−6)	−1.673	.01	(−2)	.224	.30	(−2)	.797	1.011
MS2	1.203	.01	(−6)	−1.832	.01	(−0)	.281	.20	(−6)	.731	1.082

[a]Less than 50 percent confidence that this coefficient is significantly different from zero.

Table 11

COMPARISON OF ARMY PAY ELASTICITIES
WITH DIFFERENT DISCOUNT RATES

Volunteer Group	Discount Rate	
	30%	0%
Category I, II high-school graduates	1.08	1.22
Category III high-school graduates	1.48	1.68
Category I-III	1.22	1.39

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INTERNATIONAL COMPARISONS IN MANPOWER SUPPLY[1,2]

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The analysis of all-voluntary military manpower supply in the United States naturally focuses upon U.S. conditions. In various areas important to the United States, however, this experience is special. Experience with all-volunteer forces has been brief, and past behavior has been considerably influenced by the existence of a draft and of war. Further, there has been only limited variation in military wages, entry standards, and enlistment terms, and only minor use of advertising as a recruitment device.

To gain a broader understanding of recruiting experience outside these limitations, U.S. manpower supply experience is compared with that of Britain, Canada, and Australia.

A common model of military-civilian occupational choice is specified, and appropriate estimating forms for enlistee supply are derived. For a common data period, regression estimates using joint cross-section/time-series analysis are obtained. The effects on enlistment of variations in military and civilian pay, unemployment, draft pressure, policy levels, advertising, taste changes, and enlistment term are examined and the reasons for divergence considered.

THE ROLE OF COMPARATIVE ANALYSIS

The analysis of all-volunteer military manpower supply in the United States has naturally focused upon previous U.S. experience.

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[2] A data appendix is available from the author upon request.

But in various areas important to U.S. military manpower policy, this experience is limited. There has been little experience with all-volunteer forces since World War II. Rather, enlistment behavior has been considerably influenced by the existence of a draft and of wars in Korea and Vietnam. Further, as a consequence of the availability of draft manpower, there has been only limited variation of such manpower management instruments as military wages, entry standards, enlistment terms, and recruitment advertising.

To gain a broader understanding of recruitment experience outside the special U.S. situation, this paper compares U.S. manpower supply experience with that of Britain, Canada, and Australia. Since the major English-speaking countries offer the social, economic, cultural, and political circumstances most similar to those in the United States, they form the natural comparison, as has been recognized in previous references to foreign precedent in the U.S. draft debate.[3] At the same time, these countries possess quite a diversity of experience in military manpower procurement. Canada, for instance, has long maintained all-volunteer forces, while Britain retained a National Service scheme for over a decade following World War II, only returning to all-volunteer recruitment in 1960. Finally, Australia has used each of universal military training, selective conscription, and all-volunteer enlistment for differing periods since 1946.[4]

Overseas experience cannot be directly transplanted, and comparisons must be made with the utmost care, making due allowance for the crucial differences in local circumstances that will remain no matter how carefully countries are chosen for their similarities. The very diversity of recent experience with military manpower procurement, as just outlined, indicates the importance of unique circumstances. This is also seen in the differing relative defense manpower levels among the countries. In 1973, regular military forces as a percentage of men of military age ranged from 5.8 percent for the United States through 3.3. percent for Britain and 2.8 percent for Australia to 1.8 percent for Canada (International Institute for Strategic Study, 1973-74).

But we must not lose sight of the advantages gained by supplementing direct analysis of one's own situation with comparative insights. Moreover, since such comparisons have been made in the past and will undoubtedly continue to be made, it is best that they be as informed as possible. Citation has often been highly selective and

[3] For example, see Wool (1967), pp. 517-518; Scolnick (1968), pp. 91-106; and Gates Commission (1970), pp. 169-172.

[4] A more detailed survey of the historical background in these countries is available in Withers (1972b), pp. 63-76. For a review of a wide range of other nations' experiences, see Foot (1961).

impressionistic, and we attempt here to redress this deficiency.[5] Besides, provided foreign experience is not treated as more than suggestive, we can seek solace in Boulding's First Law: "If it exists, then perhaps it is possible."

The approach we adopt here is to specify a common model of military-civilian occupational choice and to derive therefrom an appropriate estimating form for enlistment supply. For a standard data period, regression estimates of supply parameters will be obtained for each of the countries. These will then be compared, reasons for divergence will be considered, and some implications for manpower procurement policy will be drawn.

A MODEL OF ENLISTMENT SUPPLY

Recruits for the armed forces come from the pool of national manpower over the minimum school-leaving age. Women have traditionally been excluded from significant military participation, so the basic pool can be considered to comprise men only. The requirement for entry at the bottom of the military hierarchy tends to restrict recruitment from this available population to young men, since they are usually less established in civilian job progression structures. For similar reasons, those young men committed to continuing education and apprentice training programs in the civilian community tend not to enlist, further restricting the recruit population base.

What will determine the number forthcoming for enlistment from this recruit population? Each individual within this population can be viewed as facing a choice between a military job and a civilian job (the best of those civilian positions open to the individual). The individual surveys each job and considers the advantages and disadvantages of each, such as expected earnings, expected advancement, working conditions, location, etc.

In principle, these advantages and disadvantages can be classified as pecuniary and nonpecuniary, and we assume that there is some finite rate of exchange between pecuniary and nonpecuniary factors so that an individual can evaluate nonpecuniary costs and benefits in net and pecuniary terms. The individual then selects the job with the greatest overall net advantage, given those opportunities open and the individual's preferences.

The choice is made on the basis of the individual's perception of

[5] The only previously published econometric studies of military manpower supply outside the United States known to this author are Withers (1972a) and Lightman (1975). For a survey of previous econometric research in the United States, see Lightman (1973) pp. 5-14.

net advantages, which may or may not be an accurate reflection of the real net advantages. Account may be taken of the future stream of costs and benefits, with appropriate discounting for time. We thus take this as implicit, with all relevant decision variables as present values.

The individual is assumed to seek to maximize utility in terms of net advantages. There is no assertion of purely pecuniary motivation. The choice criterion is that an individual will enlist in the military if

$$WM > WC + dWC\,, \tag{1}$$

where WM is military earnings, WC is civilian earnings, and d is net taste for military life.

The coefficient d measures the individual's net preference for the nonpecuniary aspects of military life, expressed as a percentage of civilian earnings; d may be positive or negative. The coefficient thus encompasses all situations by compressing the full variety of nonmonetary considerations into the single summary measure of tastes.

Naturally, individuals in the recruit population will differ as regards their alternative civilian employment opportunities and their relative preferences for military vs. civilian life. For each person, though, we can postulate a reservation military wage, WM^*, that would make the sum of pecuniary and nonpecuniary net benefits from military employment just equal to that pertaining for the best civilian employment alternative available, i.e.,

$$WM^* = WC + dWC\,. \tag{2}$$

At the reservation military wage, each individual is indifferent between enlisting and not enlisting. If $WM > WM^*$, then the individual would enlist.

In principle, individuals may be arrayed according to their reservation military wage, creating a frequency distribution. The frequency distribution is the joint distribution of civilian earnings and relative tastes for military service. For a given WM, all individuals with reservation military wages smaller than this actual military wage will enlist. The cumulative frequency distribution of reservation military wages thus defines the supply curve of military labor in relation to alternative levels of military earnings, other things being held constant. It follows that the general form of the enlistment supply function is

$$A/RP = f(WM,\ \mu_{WC},\ \sigma_{WC},\ \mu_{dWC},\ \sigma_{dWC}) \tag{3}$$

$$= f(WM,\ \mu_{(1+d)WC},\ \sigma_{(1+d)WC})\,, \tag{4}$$

where A is applications for military enlistment,
RP is population of potential recruits,

WM is expected military earnings,
μ_{WC} is the mean value of expected civilian earnings,
μ_{dWC} is the mean value of relative military tastes,
σ_{WC} is the standard deviation of expected civilian earnings, and
σ_{dWC} is the standard deviation of relative military tastes.

From the model of rational occupational choice, it follows that we impute the following properties to military labor supply:

A positive function of the military wages $\partial A/\partial WM>0$ (5)

A negative function of the civilian wage $\partial A/\partial WM<0$ (6)

A positive function of the relative taste for military service $\partial A/\partial d> 0$ (7)

A positive function of the recruit population base $\partial A/\partial RP> 0$ (8)

The specific properties of the supply schedule will be given by the form of the joint frequency distribution of earnings and taste, (1+d) WC. A convenient simplification of the model is to assume that the variance and distributional form of the earnings and taste components of the joint distribution do not change over the period of analysis, though their mean level may. This means rewriting Eq. (4) as

$$A/RP = f(WM, \widetilde{W}C, \tilde{d}) , \qquad (9)$$

where ~ denotes mean. Note that in using an applications *rate* as the dependent variable, we assume that applications change equiproportionately with recruit population.

With this expression, WC can be written to take account of the fact that in civilian employment, unlike fixed engagement military employment, there is a chance of being unemployed, i.e.,

$$WC = p_E WE + p_U WU , \qquad (10)$$

where P_E is the probability of being employed (= $1-P_U$),
WE is expected full-time civilian earnings, and
WU is expected income while unemployed.

In addition, unemployment may have a separate effect of its own that works through risk aversion. Those who are currently unemployed or have a high probability of being unemployed may value their income prospects at something less than their mathematical expected value—

say, because of such factors as the social opprobrium or personal psychological loss attached to being unemployed. If this is so, we should include a separate unemployment variable as an argument of the supply function.

So far, this analysis is conventional; the variables obtained are standard in the military manpower supply literature. We propose three modifications that do go beyond the standard approach, however. First, since job choice is made on the basis of an individual's perception of net advantages, it is perhaps important also to include a separate variable relating to recruiting. This is because, unlike most civilian occupations *qua* occupations, the military spends considerable money and effort on recruiting. Through recruitment personnel and advertising, the military attempts to improve individual perceptions of the desirability of a military career. It is not necessary, or perhaps even possible, for such activities to create motivation for enlistment. But, given the limited information-processing and attention-retention capacity of most individuals, it can remind people of available opportunities, inform them of specific details of military life, and stimulate an existing interest. It is important to examine these effects to improve overall explanation of enlistments and because recruiting effort is a potential policy instrument.

The theory developed so far is actually one of supply offers—applications for military enlistment. What is important for military manpower strength, however, is enlistments obtained. Applications must be translated into enlistments. The conversion element is military enlistment standards, but we must recognize that this involves two considerations: the pure supply factor of the quality of the personnel that apply for enlistment, and the policy control factor of the level at which enlistment standards are set. If the variance and distributional form of quality is constant and enlistment standards are fixed, then the supply equation becomes

$$E/RP = f[WM, \widetilde{WC}, (U/RP), \tilde{d}, \tilde{R}, \tilde{Q}], \qquad (11)$$

where E is the number of military enlistments,
U/RP is the unemployment rate in the population of potential recruits,
R is military recruiting expenditure, and
Q is the quality level of recruit applicants.

The inclusion of a quality level variable is important, since only then can we infer the enlistment supply curve for a given quality level. Equally, if quality is admitted as a policy variable, then the enlistments potential of deliberate changes in the quality of applicants acceptable to the military can be evaluated. We hypothesize:

$$\partial E/\partial Q > 0\,, \tag{12}$$

since an increase in average quality will imply, other things being equal, a greater proportion of the recruit applicant population able to meet fixed enlistment standards.

Finally, we introduce a variable based on poll data to reflect changes in public tastes toward the military. This is a factor that is held constant in most analyses, but it is clearly of great potential importance, especially if there is any involvement of national military forces in actual combat service.

ECONOMETRIC METHODS

We wish to estimate the supply function given in general form in Eq. (11). It may seem natural to assume that a military labor supply function should express decreasing elasticity of supply with respect to military pay (see Altman, 1969). But the supply function depends upon the joint distribution of alternative civilian earnings and relative military tastes. For instance, there may be a range of increasing elasticity as military income becomes competitive for the populous group of middle-income earners. A normal-shaped joint distribution would have a range of increasing elasticity followed by decreasing elasticity.

We do have Lydall's (1968) evidence on distribution of incomes to indicate a log-normal distribution as appropriate for incomes of young men. But there is insufficient evidence available on the distribution of tastes and, more important, on the weights to be assigned to pecuniary and nonpecuniary preferences in forming a mixed distribution.

This inability to specify the functional form for our estimating equation presents a difficulty for adequate representation of the total supply function. However, our concern is for that limited range of the supply function for which we do have data. Accordingly, a more *ad hoc* choice of functional form may not be too misleading. To this end, logit, logarithmic, linear, and log-complement specifications were estimated and compared using the criterion of minimum sum of squares for equations in which the dependent variable had been standardized.[6]

The logarithmic form was the most commonly accepted functional form under the goodness-of-fit criterion, so that the basic estimating form employed can be written as

$$\ln\frac{E_t}{RP_t} = \alpha_0 + \alpha_1 \ln WM_t + \alpha_2 \ln WC_t + \alpha_3 \ln\frac{U_t}{RP_t} + \alpha_4 \ln d_t + \alpha_5 \ln pD_t + \alpha_6 \ln Q_t + \alpha_7 \ln R_t + e_t \tag{13}$$

[6] Rao and Miller (1971), pp. 107-111.

Only for the United States was a different specification indicated: There, ordinary linear estimation was appropriate.

The estimating equations were applied separately to total defense enlistments and to army enlistments for each country, using quarterly observations over the period 1966(2) to 1973(4). The exception to this is Canada, where annual cross-section data, 1966 to 1973, were applied to total defense enlistments only. Quarterly data were unavailable for Canada, and there are no individual service enlistments to the Canadian unified defense forces.

Single equation estimation was employed. The risk of simultaneity bias through the interrelation of enlistments, wages, and unemployment is probably small with civilian wage and unemployment variables being economywide. Also, it is likely that military manpower demand is highly wage-inelastic under established manpower requirements planning procedures.[7]

Because quarterly data are employed, we add seasonal dummy variables to Eq. (13) to control for seasonal influences upon enlistment rate variations. Serial correlation is adjusted for by the Cochrane-Orcutt iterative process.

The basic set of supply estimations is thus alternate defense and army dependent variables for three countries. Canada is the exception, since its unified defense force means that only a defense dependent variable was available.

For all countries, an additional set of regressions was also performed, replacing separate military and civilian income variables by a single wage ratio. This has the advantage of avoiding potential multicollinearity both between the income variables and with other independent variables. In the use of a wage ratio, the cost is the implicit assumption of symmetric response to alternative income changes.

In the formulation of the model it is assumed that the dependent variable responds instantaneously (quarterly) to current changes in the independent variables. We did test this assumption by estimating equations that incorporated a lagged dependent variable as a convenient formulation of a distributed lag process. The lagged dependent variable was not significantly different from zero for three of the four countries, though the U.S. results did indicate a small lag. Longer-run elasticities will thus be a little larger than the "impact" elasticity reported for the United States. To simplify presentation, we discuss results for the instantaneous adjustment model only. This does not alter the substance of the comparative analysis.

[7] For a statement of U.K. manpower planning procedures that is quite explicit in its emphasis on fixed coefficient requirements determination totally divorced from cost and supply considerations, see U.K. Department of Employment (1974).

Empirical Results

A total of 16 ordinary least-squares regressions were run for the four countries: four each for Great Britain, the United States, and Australia on quarterly time-series, 1966-1973; two joint cross-sections of time-series for Canada; and, in a supplementary analysis, two also for Australia. The regressions examined the effects of the specified independent variables upon enlistment supply for the army and total defense and with alternative specifications of the pay variable.

Table 1 summarizes the basic results in elasticity form. The elasticity interpretation is immediate for those equations estimated in natural logarithms. Linear estimation was used for the United States, so that elasticities are evaluated at the mean values of the variables.

The coefficient of determination (R^2) was high for almost all equations, which indicated a good fit to the data by the equations used. While we often do expect reasonably high R^2s for time-series analysis, this is still quite an encouraging result for a sectoral series in which most of the variables used are constructed as ratios or percentage rates. The lower R^2 for the Australian pooled cross-section and time-series regression was expected through the introduction of more individual variance characteristics.

Military and Civilian Income

Looking at the individual explanatory variables and commencing with income, we find considerable variation in results from country to country. The estimated income coefficients for Britain indicate a significant and relatively high income elasticity for manpower supply, over the period of analysis. But for the other countries, evidence of such an effect is less clear. Thus, for the Canadian regressions and for the U.S. and Australian time-series analysis, the absolute pay model produces income elasticity estimates often of the "wrong" sign and not significantly different from zero. And, except for the United States, the standard relative pay model estimates also attribute little influence to income in explaining enlistment rate variations over the period.

In each of these countries, real statistical problems underlie the measurement of the effects of pay variations. A strong collinearity between military and civilian pay movements, due to military wage-setting procedures, tied military wages closely to movements in civilian wages during this period. In Canada there was, over the whole period, no major shift at all in military-civilian pay relativities, and in the United States and Australia there was only one major relative pay change that significantly altered those relativities.

The result is simply an inadequate range of observations for differential military and civilian pay changes, so that meaningful results on

Table 1

Regression Analysis Results: Elasticities of Enlistment Rate Supply

Relative Income Model	Relative Income	Unemploy-ment	Quality Acceptance	Draft Pressure	Military Tastes	Recruiting Effort	R^2	Durbin-Watson Statistic
Army								
Australia	-0.27	0.34**	1.12**	0.02*	-0.001	0.01	.93	1.42
Britain	-1.52**	0.90**	0.79**			-0.07	.96	1.42
United States	-0.28*	-0.29*	0.80**	0.18**	0.15*		.90	1.75
Australia (CS-TS)[a]	-1.48**	0.17*	0.86*	-0.01			.56	
All-defense								
Australia	0.25	0.17*	0.93**	0.00	0.04		.88	1.85
Britain	-1.58**	0.79**					.89	1.72
United States	-0.52**	-0.39**	0.98**	0.05*	0.28*		.98	1.74
Canada (CS-TS)[a]	-0.99	0.29	0.96**				.98	2.73

Absolute Income Model	Civilian Income	Military Income	Unemploy-ment	Quality Acceptance	Draft Pressure	Military Tastes	Recruiting Effort	R^2	Durbin-Watson Statistic
Army									
Australia	-0.95	0.09	0.37**	1.07**	0.02*	-0.18	0.05	.93	1.46
Britain	-1.15*	1.46**	0.90**	0.81**			-0.06	.96	1.44
United States	1.98	0.09	-0.19	0.28**	0.18**	0.17*		.90	1.75
Australia (CS-TS)[a]	-1.19**	2.44**	0.16*	0.90**	0.04			.61	
All-defense									
Australia	0.13	-0.30	0.19*	0.93**	0.00	0.00		.88	1.84
Britain	-1.73*	1.59**	0.80**					.89	1.72
United States	-1.43	0.45**	-0.38**	0.98**	0.05*	0.22*		.98	1.72
Canada (CS-TS)[a]	-3.60	1.37	-0.10	1.09**				.98	2.23

* t-value significant at the 0.10 level.

** t-value significant at the 0.05 level.

[a] (CS-TS) indicates regression on pooled cross-section and time-series data.

the influence of altering pay relativities are difficult to obtain. What we do have are equations that can be used to analyze recruiting under a compensation policy stressing the maintenance of military-civilian income parity. In this context, we could then turn to analyzing which other variables play a significant role in influencing variations in enlistments.

At the same time, complete agnosticism is not necessary on the role of altering pay relativities. Where collinearity is present in data, the solution is to turn to extrasample evidence. In our case, we already have the evidence from Britain, where pay relativities have been more frequently altered and where recruiting-directed pay changes have had clearly significant effects upon inducing enlistments. Evidence is also found in other studies of the United States and Australia covering earlier periods where greater divergence of civilian and military wages occurred either through deliberate military wage changes or through civilian wages moving ahead of fixed military wages—e.g., Fisher (1970) and Withers (1972a). In both cases, larger and more statistically significant income elasticity estimates were obtained from quarterly time-series data for earlier periods.

Finally, whereas the regressions reported tended to rely upon aggregate time-series data, cross-section data for that same period could provide greater variability in relative military-civilian wages, since military income is uniform nationally, whereas average civilian incomes vary regionally. We already did this for Canada, but Canada operated in an excess supply situation for a long time, so that enlistment variations are dominated by quality acceptance rate variations, leaving little explanatory role for other variables. A better test is with Australia.

Data for Australia were available on a quarterly disaggregated basis, so a supplementary regression analysis was carried out using ordinary least squares with individual constant terms, the latter representing the Australian states. Analysis of covariance supported the hypothesis of the homogeneous slopes and rejected that of homogeneity of intercepts. The results are reported in Table 1 as "Australia (CS-TS)" and indicate the existence of highly significant, negative, relatively large income elasticities over that period, under both relative pay and absolute pay specifications and without greatly altering coefficient estimates for other variables. This affirms the importance of collinearity in reducing the explanatory power of income measures in our regular time-series analysis, so that the U.S. results in this area should be considered open to further examination also.

The Unemployment Rate

The second economic variable included in the regression analysis was the unemployment rate, justified as a proxy for risk aversion and for variation in the distribution of civilian earnings. In all cases, elasticity estimates were less than unity, but otherwise a clear divergence in results among the various countries is evident. For Britain and Australia, elasticity estimates are significant and positive; for Canada, they are not significantly different from zero; and for the United States, they are significant and negative.

For both Britain and Australia, the enlistment rate increases as the unemployment rate increases, the effect being larger and more statistically significant for the army than for total defense enlistments. The likely explanation is that in both countries the navy deliberately seeks to attract younger recruits direct from school for long-term engagement, and the air force attracts higher-quality recruits with good civilian alternatives. The army, with short service terms available, is more likely to receive applicants in connection with increasing unemployment.

The British unemployment elasticities tend to be greater than those estimated for Australia but are still less than unity. The lower absolute level for Australia is consistent with Australia's experience of continued full employment; until 1974, annual registered unemployment rarely rose above 2 percent. Over the period analyzed, Australian unemployed would have had more confidence in being able to obtain a job.

The Canadian and American experiences require different interpretation. For Canada, the unemployment rate contributes little to the explanation of enlistment variation, because of the absolute dominance of the quality acceptance variable, which we discuss further below. The Canadian military is the smallest, relative to population, of the four countries, and it has easily the highest average military-civilian income relativity for the years analyzed. The result is that the Canadian military has long operated with an excess of applicants meeting military standards, so that pay and unemployment effects are not reflected in the enlistments into the military during the recent past.

The American results show that the unemployment rate is a statistically significant explanatory variable but that its influence there has been negative. The army elasticity estimates here are also absolutely smaller than for total defense, supporting the earlier hypothesis that as unemployment rises, individuals apply more to the army than to the other services. But this does not explain the net result of still negative signs for both elasticity estimates.

A conceivable rationalization is that as unemployment rises, those being laid off first are not acceptable to the military and are thus rejected. As unemployment decreases, more people may be willing to quit jobs and investigate new careers, and these people would be of acceptable quality. But this rationale should apply equally to Britain and Australia, and besides we are able to control for quality effects with the use of a separate quality acceptance variable. Clearly, other explanations must be sought. One possible reason is that American entrance standards became much higher during the long period when a draft was in effect, so that at a time of secular increase in the unemployment rate there was a corresponding increase in enlistment standard requirements. Canby (1972, p. 36) has affirmed a steady increase in rejection rates under the draft—primarily in the area of increased rejections of applicants in lower mental categories at a time of increasing general level of education—so that this would seem one element of such an explanation.

Another (complementary) reason may lie in the different nature of U.S. unemployment compared with that in Australia and Britain. Recent literature, typified by Hall (1970) and Feldstein (1973), has argued that unemployment in the United States has become high not because of insufficient vacancies or job loss but because of increased voluntary separations and withdrawals associated with the "secondary labor market" of women, youths, and blacks. Such problems seem to apply less to Australia and Britain, in part because education is more vocation-oriented, with less emphasis upon formal academic qualifications. Also, the greater unionization of labor in both Britain and Australia and a greater emphasis upon working conditions probably have meant less of a "dual labor market" there than in the United States. Finally, the structural problems with regard to youth and minorities are less for Britain and Australia. Britain, for various reasons, does not have the same age structure problems as the United States, and Australia has not had a similar minority problem.

Quality Acceptance Rate

The individual explanatory variable that is uniformly the most significant in terms of statistical confidence levels is the quality acceptance rate. This was measured as the proportion of applicants who were accepted and enlisted into the military, except for the United States, where the proportion of Mental Category IV enlistees in the total enlistment had to be accepted as a proxy in the absence of a comparable applications series. Estimation on this basis indicated that variations in the quality acceptance rate were a key influence upon enlistment rate variations.

The sign of the estimated coefficient for quality acceptance is uniformly positive, as expected, and the coefficient is estimated to provide an elasticity of around unity, as is also expected *a priori*. Indeed, it might have been assumed that this coefficient could be constrained to equal 1: a 1 percent increase in enlistments that a 1 percent increase in the proportion of applicants accepted would lead to. This is not strictly true, however, since various demonstration effects may accompany changes in applicant acceptance. Given the extent to which young men hear about military career opportunities informally through the experience of their peers in applying for entry to the military, a higher than average rejection rate may well induce a change in the number applying for entry.

A real difficulty in interpretation of this quality variable, as it is constructed, is that it may reflect simultaneity. This would be the case with "creaming" of applicants in cases of excess supply, with quality here becoming the market equilibrating variable. This is more likely to influence total defense enlistment estimation rather than army only, since excess demand situations tend to typify the latter.

Regressions without the quality variable do lower R^2, as expected, but do not significantly alter the coefficient estimates on the other variables. It was therefore felt appropriate to retain the quality acceptance variable as an indicator of the enlistments potential of deliberate (policy) increases in the proportion of applicants (or Mental Category IVs) acceptable for military service. In a revised analysis, results would be improved if data could be obtained that actually measured quality level itself—e.g., a weighted average of aptitude scores of enlistees. No such data were available for this study for all countries, though its potential use is well illustrated in a study of U.S. Air Force enlistments by Cook and White (1970).

Draft Pressure

The draft pressure variable applied only to the United States and Australia. For Australia, there is no evidence of a major effect of draft pressure upon enlistment rates. This result is not unexpected, since the Australian draft took only a small percentage of eligible young men and used a 20th birthday ballot, which gave certainty as to draft status and apparently induced most young men to take a chance on being drafted. Also, there were few pay, promotion, or occupational specialty benefits to be gained by volunteering as opposed to being drafted.

The estimates of U.S. draft pressure effects yield more significant coefficients, with most of the effect operating through induced army enlistments. The elasticities are positive, as expected, but indicate a lower draft pressure effect than has been previously assumed, on the basis of the U.S. Department of Defense motivation surveys conducted in 1964 and 1968.[a]

[a] For details of these surveys and a discussion see Gilman (1970), pp. 4-10.

No doubt, the difference is in part explained by the fact that the time period used for our regression analysis included the switch to a lottery draft in 1970. This means that the coefficient measures the *net* draft pressure effect of two draft systems, the latter of which can be expected to have much less influence than was true for the system operating when the motivation surveys were undertaken. This also means, of course, that fears of a loss of induced enlistments, based on the earlier motivation surveys, were misplaced when it was a lottery draft whose abolition was being considered. This conclusion is certainly supported by the Australian results with a lottery draft.

Of course, where the true draft pressure effect of the pre-lottery U.S. Selective Service System lies is not clear, for while it will be greater than is indicated by our time-series finding, it will also probably be less than is given by the survey results, since these had a number of limitations regarding timing, coverage, method of administration, and form of questions asked, most of which would tend to bias the survey results upward in estimating a draft pressure effect (Gilman, 1970).

Military Tastes

In the absence of continuing poll data on public attitudes toward the military or military service in Britain and Canada,[9] a constant level and distribution of tastes for military service had to be assumed for those countries. Since for Canada there was no combat involvement or major restructuring of nonpecuniary conditions of service, this is probably satisfactory. It might be less so for Britain, with the situation in Northern Ireland and the decline of overseas service opportunities, but the one bit of survey evidence we do have, which covers the period since 1971, actually indicates little change in public attitude toward a military career.[10]

The involvement of Australia and the United States in the Vietnam conflict, with the associated effects on objective conditions of service and public attitudes toward the military, means that more direct attention must be paid there to the role of tastes. To test this in the regression analysis, we used the surrogate measure of response

[9] A search was made of available public poll data filed at the Roper Public Opinion Research Center, Williams College, Massachusetts (October 1974), as well as of unpublished surveys for the relevant ministries.

[10] Unpublished surveys by NDP Market Research Ltd., Ministry of Defence, London. These surveys represent quarterly polls conducted since April 1971 and include questions dealing with attitudes toward the Armed Forces in general and military careers in particular.

to Gallup Poll questions on the Vietnam War ("Whether the U.S./Australia made a mistake in sending troops to Vietnam"). *A priori*, for the United States we would expect Vietnam to have been a positive influence early in the war, through its appeal to patriotic, adventure, travel, and pecuniary motivations for enlistment, but becoming less so as public doubts about the wisdom of the commitment increased.

The regression analysis indicates a moderate positive influence upon enlistments for the United States, with no significant difference between the effects on army and other services' enlistments. The implication is that participation in Vietnam, on balance, encouraged net enlistments over the period.

In Australia, the public opinion parameter estimates are not significant, are not consistent in sign, and produce estimates of elasticity of quite small magnitude. This result is, however, compatible with the different domestic experience Australia had in relation to the Vietnam war, compared with that of the United States. In Australia, participation in the Vietnam war was exceedingly controversial from the beginning, even before conscript troops were committed to service in Vietnam. The use of Australian troops directly violated strongly held Labour Party foreign policy beliefs, and Labour opposition to Vietnam involvement was violent and trenchant. There was no period in Australia when service in Vietnam was not under question, so that patriotic motives for enlistment were considerably dimmed. Australian experience in jungle and guerrilla warfare in New Guinea, Malaysia, and Indonesia also left few public illusions as to the difficulties to be faced in Vietnam, so that any thoughts of adventurism in enlisting were also reduced. Finally, Australian overseas service allowances and benefits were quite minimal compared with U.S. provisions, and living conditions in Vietnam were much less comfortable for Australian servicemen.

In the United States, public opposition to the war never really developed until after the 1968 Tet Offensive, and widespread public understanding of the nature of an insurgent civil war was longer in coming. The result was a period when patriotic, adventure, and pecuniary motives would join to encourage enlistment and so produce an average positive influence upon enlistment. The exact level of this effect implied for the United States may not, however, be that given by our estimates, since there is some collinearity between draft pressure and the Vietnam public opinion variable. The simple partial-correlation coefficient is .77, and exclusion of either the draft or the taste variable in estimation does increase the size of the remaining coefficient and its statistical significance, which may also contribute to some underestimation of the defense draft induction effect.

Recruiting Effort

It was important to examine recruiting effort effects, both to improve overall explanation of enlistments and because recruiting effort is a potentially important policy alternative to military wage changes in obtaining voluntary enlistments.

For Australia, we were able to measure recruiting effort by number of military personnel assigned to recruiting duties; and for Britain, we used recruitment advertising expenditure. Adequate series were not provided for Canada or the United States.

For Britain and Australia, the recruiting effort variables employed did not produce estimates of coefficients significantly different from zero. The size of the coefficients also meant a very small elasticity estimate. Since there was adequate variation in these variables and no evidence of collinearity problems, it would seem that adjustments in the level of army recruitment effort over the range of previous experience are not a very effective means of altering levels of recruitment. Of course, what would happen for very large increases or decreases in such effort is a question unanswered here. It could be, for instance, that a certain "floor" level of recruitment advertising and personnel activity is needed to maintain awareness of service opportunities, even if beyond this point there is low marginal effectiveness to additional recruiting efforts. There is evidence from the United States, advanced by Epps (1973), that the *introduction* there of paid prime-time recruitment advertising in 1971 did contribute substantially to military enlistments at the time. But again there is no conclusion on the longer-term effects (post-1971) or on the effectiveness of subsequent variations in expenditure. Until further evidence is obtained, it would be unwise to rely upon changes in recruitment effort as a flexible instrument for enlistment policy.

Enlistment Term

Our evidence on the effect upon enlistment rates of altering the length of fixed engagements offered is limited. Canada actually uses indefinite career engagements with release on request. Elsewhere, fixed enlistment terms of career engagement range from a minimum of three years for army enlistments in the United States to a maximum of 12 years for some Navy artificer trades in the Royal Navy. Most engagements are for three- to six-year periods. But the only change in engagement terms identified was a shift to a shorter, three-year engagement option for the army in the United Kingdom.

A dummy variable introduced to test the effect of this British change in enlistment terms produced neither a large nor a highly significant coefficient, so that while a substantial number of recruits did enter under this scheme (Kemp, 1970, p. 19), it seems that they were largely men who would otherwise have signed up for a longer engagement. The effect of such changes could be greater if liberal "discharge-by-purchase" arrangements were not as readily available as they are in the United Kingdom for army service.

IMPLICATIONS OF OVERSEAS EXPERIENCE

Argument by analogy is a notoriously poor substitute for direct and thorough analysis. Particularly with intercountry comparison, crucial differences in local circumstances will remain, no matter how carefully the countries are chosen for their similarities.

Comparative study can be justified as being of interest in satisfying natural curiosity. But such curiosity itself can generally be seen as deriving from a deeper motive, that of learning. Just as we can turn to history for the lessons it may offer from different or broader previous experience, so we can also turn to the experience of other countries for a broader perspective. And provided intercountry comparisons are accepted as suggestive only, they clearly represent a useful form of supplementary analysis.

In our case, we sought to gain insights from the military manpower supply experience of four culturally similar nations: Australia, Britain, Canada, and the United States. A theoretical model of occupational choice was developed and used to specify an econometric supply function for military enlistment. The parameters of this function were then estimated for each of the countries, using regression techniques, and the results were compared, their similarities being discussed and divergences analyzed.

It was seen that the economic factors of wage levels and unemployment rates do play an important role in influencing enlistment rate variations, contrary to some expectations that pecuniary considerations would not influence the choice of military employment. It is thus important that these economic factors be fully considered in military manpower planning and management.

For policy use, military wage variations are affirmed as an important instrument for recruitment, even though this importance may be hidden when there is an equity-based linking of military wages to civilian wage movements. A potential for influencing the enlistment rate by deliberate alteration of military-civilian wage relativities still exists, and British and Australian experience indicates that elasticities of unity or larger may apply for the range of moderate peacetime military manpower requirements.

Unemployment changes are also seen as being necessary to consider in recruitment policy. Elasticities were uniformly found to be less than unity in absolute value. But with a low base, a change of a few percentage points in the unemployment rate can imply a large *percentage* change in the unemployment rate—e.g., to move from 6 to 9 percent unemployment is a 50 percent change—with significant potential implications for recruiting even with elasticities below 1.

The exact form of influence of unemployment will vary greatly with the national labor market structure and the previous history of unemployment experience, so that in some cases unemployment rate changes can be a positive influence upon recruiting and in others a negative influence. The implications of changes in labor market structure, say, through national manpower programs, and of changes in the national experience with unemployment should therefore be closely watched for their possible effects on changing the way in which unemployment affects recruitment.

The way in which draft pressure influences voluntary enlistment was seen to be perhaps less for the United States than had previously been accepted. It was shown by the comparison between Australia and the United States to depend upon the level of operation of the draft and its structure—factors that will need to be taken into account when standby draft arrangements are planned.

A need for close attention to reviewing the process by which inquiries on and applications for military enlistment are transformed into realized enlistments is indicated by the key importance uniformly found to attach to variations in the quality acceptance rate in explaining variations in enlistment rates. Comparative experience emphasizes the vital role played by the quality of supply offers forthcoming and the acceptability of those offers to the military, yet this factor has not generally been fully appreciated in most economic analyses of military manpower supply; much more needs to be done.

To give one indication of the potential in this quality-acceptance area, in Australia over the past decade the *Annual Reports* of the Director-General of Recruiting indicate that applications to enlist were three times greater than actual enlistments and formal registered inquiries about enlistment were four times greater than applications. The interest in military employment is clearly there.

In contrast to the quality-acceptance variation, the comparative analysis found little evidence to support the use of recruitment effort and terms of engagement as flexible instruments of recruitment policy. However, our information on these policy areas was more limited than for other variables, so the need for more research is evident. But until such evidence is obtained, it would be unwise to view recruitment effort and engagement terms as *flexible* policy variables.

Military tastes were seen to be of importance for U.S. enlistments during the Vietnam war, which emphasizes the need to develop more satisfactory continuing measurement of attitudes toward military careers and for incorporating this information into manpower supply analyses. Again, as with quality acceptance, this is an area of great potential importance that most supply analyses by economists have tended to neglect. Measuremont in this area is bound to be imperfect, but such information will still form a useful supplementary tool in recruiting analysis. Such analysis is hardly improved by entirely ignoring the matter of changes in attitudes toward the military.

The implications we have drawn from the recent experience of the major English-speaking countries are supply-oriented. The next task is the integration of manpower supply analysis with that of manpower requirements. The basic approach adopted here does lend itself readily to that further development, though we should emphasize that the specific conclusions reached above apply to the range of manpower requirements experienced by the four countries over the last decade.

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MODELING RECRUITING DISTRICT PERFORMANCE[1]

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The number of enlistments in Navy Recruiting Districts during CY 1973 and FY 1975 is related to the number of recruiters and the size of the quota after controlling for differences in district demographic and economic characteristics. For both years, recruiters had very little effect at the margin, while quotas inhibited recruiter productivity and reduced the number of enlistments. Setting different quality requirements for each district would enhance recruiter productivity.

INTRODUCTION

Knowing the characteristics of individuals with a high probability of surviving the first term of service is helpful to the services in their recruiting efforts, of course. But it would also be helpful to know where such individuals are most likely to be found, and whether Recruiting Command policy can be changed to increase their recruitment. For these reasons, we investigated the determinants of enlistments in the 42 Navy Recruiting Districts (NRDs).

ECONOMIC AND DEMOGRAPHIC INFLUENCES ON ENLISTMENT RATES

The boundaries of the 42 NRDs in CY 1973 were drawn such that

[1] The ideas expressed in this paper are those of the authors. They do not necessarily represent the views of either the Center for Naval Analyses, the United States Navy, or any other sponsoring agency.

the only geographical unit that remained intact was the county. From the 1970 Census of Population [1], we aggregated counties into Recruiting Districts and calculated weighted averages for various population, employment, and income statistics.[a]

The enlistment rate, E, for the i^{th} recruiting district is calculated by dividing the number of male non-prior-service accessions for CY 1973 by the number of 17 to 21 year old males, M, residing in the district ($E_i = A_i/M_i$). Our estimate of the eligible population is less than ideal in several respects. First, each M_i itself is simply the product of the total male population in the district (from the Census data) and the fraction of the total U.S. male population that was 17 to 21 years of age during CY 1973. We are thus implicitly assuming that the age distribution of the male population is the same in each district. Second, we have not adjusted the M_i for differences in eligibility for military service across districts. Some districts may be more heavily populated by young males who are likely to be ineligible for military service because of poor performance on entrance tests, low educational attainment, or physical disabilities. Our estimate of the M_i does not adjust for this possibility.

We postulate that E is a function of the following variables:

- BLACK — the proportion of the total population that is black,
- URBAN — the fraction of the total population living in urbanized areas and in places of 2,500 inhabitants or more outside urbanized areas (Census definition),
- EDUC — the median years of education for the total district population,
- U — the unemployment rate of the total civilian labor force,
- MIX — the proportion of the total civilian labor force employed in manufacturing,
- PCI — district per capita income (in thousands of dollars), and
- NETMIG — the percent net migration into (or out of) the district between 1960 and 1970.

$$E = f(BLACK, URBAN, EDUC, U, MIX, PCI, NETMIG) \quad (1)$$

These variables were chosen because of the availability of data on them, and because earlier studies found many of them to be signifi-

[a] The Newark District became a separate entity midway through CY 1973, so we merged it with the New York City District (of which Newark had originally been a part), leaving us with 41 observations for analysis.

cantly related to enlistments. (See, for example, Refs. 2, 3, and 4.) The exact qualitative influence of many of them is still ambiguous, though. This is further complicated by the fact that the M_is are not accurately estimated. Thus the estimated effect of the explanatory variables listed above may not only reflect variations in enlistment rates, but also may reflect errors in the estimates of the M_i. In particular, underestimates of M_i will imply E_i that are biased upwards, while overestimates of M_i will imply downward-biased E_i. Thus, for example, any explanatory variable associated with underestimates of M_i will appear to have a positive effect on enlistment rates.

We estimated several functional forms of Eq. (1). The best performer was generally the logit form, or

$$\ln\left(\frac{E}{1 - E}\right) = \beta_0 + \sum_{j=1}^{n} \beta_j X_j \qquad (2)$$

where ln indicates the natural logarithm, the X_j are the explanatory variables listed above, and β_0 and the β_j are the constant term and coefficients to be estimated.

Table 1 presents results for total enlistments. The results are interesting for several reasons. First, note that the explanatory variables "explain" 68 percent of the variation in enlistment rates, as the R^2 of .68 indicates. Second, the signs of the coefficients are consistent with predictions of economic theory and previous studies of enlistment behavior. Third, the coefficient on BLACK is negative and strongly significant, indicating that the Navy has had relatively poor recruiting success in heavily black districts.

Several important questions are raised by these results. The observed number of enlistments from each district is not only a function of potential recruits' propensity to enlist. It is also a function of the Navy's quality restrictions. That is, the Navy does not accept *all* individuals who wish to enlist, but only those who meet minimum quality requirements. If the likelihood that a potential recruit meets the Navy's minimum quality standards varies across districts, then the regression in Table 1 is not analogous to a pure supply function, but also has elements of a demand function.

Table 2 presents results for a regression where enlistments are more narrowly defined to include only enlistees who are both school-eligible and high-school graduates. The definitions of all other variables are unchanged. We expect this regression to be more analogous to a pure supply function, since the Navy will accept virtually all volunteers who are both school-eligible and high-school graduates. The results in Table 2 are essentially the same as those in Table 1, but,

Table 1

REGRESSION RESULTS FOR LOGIT ENLISTMENT MODEL:
TOTAL ENLISTMENTS, CY 1973

Explanatory Variable	Coefficient	t-value	Elasticity[a]
Constant	−5.91	−8.59	
BLACK	−1.54	−4.33	−0.17
URBAN	0.382	1.34	0.26
EDUC	0.200	2.83	2.30
U	3.19	1.54	0.14
MIX	0.577	1.65	0.14
PCI	−0.585	−4.65	1.69
NETMIG	0.497	1.61	0.01

n = 41
R^2 = .68
F = 11.3

[a]$\text{Elasticity}_j = \overline{X}_j(1 - \overline{E})\hat{\beta}_j$, where the X_j are the explanatory variables, E is the enlistment rate, and the $\hat{\beta}_j$ are the estimated coefficients. The bars indicate that the variables are measured at their means.

Table 2

REGRESSION RESULTS FOR LOGIT ENLISTMENT MODEL:
SCHOOL-ELIGIBLE HIGH-SCHOOL GRADUATE ENLISTMENTS, CY 1973

Independent Variable	Coefficient	t-value	Elasticity
Constant	−8.35	−11.29	
BLACK	−2.12	− 5.54	−0.24
URBAN	0.0408	0.133	0.94
EDUC	.391	5.15	4.52
U	8.76	3.93	0.38
MIX	0.115	0.304	0.03
PCI	−0.676	− 4.99	−1.96
NETMIG	0.591	1.78	0.02

n = 41
R^2 = .86
F = 29.5

as expected, the quality of the regression itself has increased. The R^2 is higher (.86 compared to .68) and the t-values on six of the coefficients are higher, indicating greater statistical significance.

Of particular interest in Tables 1 and 2 is the strong negative coefficient on the BLACK variable. It is natural to wonder what this result implies. It may, of course, merely reflect a distaste for the Navy on the part of blacks. It may also reflect a systematic failure to recruit blacks on the Navy's part. We have no additional evidence to present on this issue, except to note that the Navy has generally done better recruiting blacks in rural areas than in urban areas.

One factor we have thus far omitted from our analysis is the effect of Recruiting Command policy. The results in Tables 1 and 2 may be biased by this omission. The next section assesses the importance of policy variables.

THE EFFECTS OF RECRUITING COMMAND POLICY

Data were available on three Recruiting Command policy variables: district budgets, the number of production recruiters (canvassers) assigned to each district, and district recruiting goals (quotas). Unfortunately, the budget data were not suitable for our purposes here. Thus we present results only for the effects of canvassers and quotas.

Canvassers

The canvassers (recruiters) the Navy distributes among the NRDs can be expected to influence enlistment rates for two principal reasons. First, canvassers deliver information to potential recruits. Information about pay, fringe benefits, possible job assignments, and the like may be more efficiently delivered by other means, such as advertising, but the canvasser is also the potential enlistee's only direct contact with the Navy. As such, the recruiter's experiences, anecdotes, and descriptions of a Navy career represent important information which would be difficult to provide in any other fashion. Because this information is, for the most part, delivered on a one-to-one basis, we should expect the number of canvassers to have a positive and perhaps sizable effect on the enlistment rate.

Canvassers also serve a screening and processing function. This involves conducting personal interviews, administering tests, and making background investigations. A larger number of canvassers in a district should allow this function to be performed more thoroughly, but it need not have any direct effect on overall enlistment rates. What is more likely, however, is that a larger number of canvassers should allow for improved quality of actual enlistees.

This discussion suggests, then, that the number of canvassers may be an important additional determinant of the enlistment rate in an NRD. The next question to ask is, How should we expect the number of cavassers to interact with the demographic and economic variables that influence enlistment rates? That is, What is the appropriate functional form for estimating the effect of canvassers? Economic theory and our discussion of the effects of canvassers suggest several properties that an appropriate functional form should have

Because of the processing and screening function that canvassers perform, as the number of canvassers approaches zero, the number of enlistments should also approach zero. That is, in the absence of canvassers, *other things remaining the same*, no one would be able to enlist in the Navy. As the number of canvassers rises, the number of enlistments should rise. Enlistments may rise nearly proportionately at first, but increases in the number of canvassers should soon increase enlistments at a diminishing rate. Finally, when the number of canvassers is sufficiently large, additional canvassers should have little or no effect on enlistments. While an additional recruiter may not be able to induce any additional enlistments, he should not *discourage* any. Therefore, we expect that increases in the number of canvassers should never decrease the number of enlistments.

On the basis of the evidence presented here, and in other studies of enlistment behavior, it is reasonable to assume that the effect of canvassers should depend on the economic and demographic characteristics of the NRD. In districts where potential recruits have a high propensity to enlist, additional canvassers should increase enlistments more than in NRDs where the propensity to enlist is lower.

This discussion implies that an appropriate functional form will have the following properties:

1. As the number of canvassers (C) approaches zero, the number of enlistments (A, for accessions) should approach zero: $(C \to 0 \Rightarrow A \to 0)$.
2. The marginal product of canvassers $(\partial A/\partial C)$ should always be greater than or equal to zero: $((\partial A/\partial C) \geq 0)$.
3. The marginal product of canvassers should diminish as the number of canvassers increases: $((\partial^2 A/\partial C^2) < 0)$.
4. The marginal product of canvassers should vary across districts as a function of the district's economic and demographic variables (X_j): $[(\partial A/\partial C) = f(X_j)]$.
5. Proportional increases in the eligible population, the number of canvassers, and the quota should lead to proportional increases in enlistments.

We considered a number of functional forms that had some or all of these properties. Two of them consistently outperformed the others in terms of statistical criteria and also had all or most of the five properties listed above. They were the logit function, Eq. (2) above, and a "log-interaction" function:

$$\frac{A}{\lambda} = \beta_0 \ln \frac{C}{\lambda} + \sum_{j=1}^{n} \beta_j X_j \ln \frac{C}{\lambda}. \tag{3}$$

In Eq. (3), $\lambda = M_i/\overline{M}$. This procedure thus standardizes all districts so they are of "average" size.

We discuss the actual estimate of Eqs. (2) and (3) below. For now, we shall describe the more general results we obtained when estimating all functional forms. In all regressions, all the variables shown in Tables 1 and 2 were included, as well as a canvasser variable and several other policy-related variables.

In all cases, the canvasser variable had a positive and strongly significant effect on enlistments. Its inclusion in a regression did not alter the signs of the coefficients on the other explanatory variables (shown in Tables 1 and 2). In functional forms where $\partial A/\partial C$ and $\partial^2 A/\partial C^2$ were not constrained to conform to our *a priori* expectations, both usually had the correct sign. That is, $\partial A/\partial C$ was positive, indicating a positive marginal product of canvassers, and $\partial^2 A/\partial C^2$ was negative, indicating a decreasing marginal product with increases in canvassers.

Quotas

In addition to a cavasser variable, we also included a measure of the quota or goal assigned to each NRD. While the NRD's quota is not a fixed ceiling in the sense that enlistments in excess of the goal are forbidden or severely restricted, the quota might be expected to serve as a negative incentive for canvassers to greatly exceed quotas.

The Navy generally evaluates the performance of an NRD on the basis of whether its quota was met and, to a lesser extent, on the basis of the degree to which it was exceeded. More important, if all NRDs were to exceed their quotas for a year, the Navy would exceed its Congressionally mandated end-strength or be forced to release other personnel. In short, if recruiting goals were habitually exceeded, this would create some serious personnel management problems. For these reasons, then, we expect that quotas should have some negative influence on enlistments.

This expectation was confirmed by our empirical work. When quotas were entered as an explanatory variable in our regressions, that variable always had a positive and strongly significant coefficient. This means that higher quotas were associated with higher enlistments. Of course, this result would not be surprising if the Recruiting Command "perfectly" allocated quotas, in the sense that the quota accurately reflected the expected number of enlistments in a district. However, we have been told by members of the Recruiting Command staff that this is not very likely. We interpret our results (and other results not presented here) as evidence that quotas do lessen the effect of canvassers.

This conclusion, incidentally, is one that the Recruiting Command has drawn independently. As a result, the Recruiting Command is now considering alternatives to setting quotas.

The Marginal Product of Canvassers

While it may be comforting to confirm that canvassers do not have a negative influence on enlistment rates, it is hardly a surprising result. Thus it is desirable to know more than the simple fact that more canvassers implies more enlistments. We would also like to know the effect on enlistments of *additional* canvassers and how this effect varies across recruiting districts.

For this purpose, we wish to use a regression that is "best" in terms of predicting enlistments. The log-interaction functional form produced regressions that had the lowest standard errors of estimate and the highest adjusted R^2. Table 3 presents the results of our best regression for school-eligible high-school graduate enlistments. In this regression, the QUOTA variable was divided by λ and was also entered as its natural logarithm to account for the expectation that increases in quotas should have a diminishing effect on enlistments.

The results in Table 3 are very similar to those in Table 2, which did not include the effects of canvassers and quotas. The URBAN and MIX variables are not included here because they do not improve the explanatory power of the regression reported in Table 3.

Of particular interest here, however, is what the results in Table 3 imply about the marginal product of canvassers. Recall that Table 3 is the result of an estimate of Eq. (3):

$$\frac{A}{\lambda} = \beta_0 \ln \frac{C}{\lambda} + \sum_{j=1}^{n} \beta_j X_j \ln \frac{C}{\lambda} \qquad (3)$$

Then the marginal product of canvassers in the i^{th} NRD is

$$\left(\frac{\partial A}{\partial C}\right)_i = \frac{\lambda_i}{C_i} (\beta_0 + \sum_{j=1} \beta_j X_{ij}) . \qquad (4)$$

Table 3

REGRESSION RESULTS FOR LOG-INTERACTION ENLISTMENT MODEL: SCHOOL-ELIGIBLE HIGH-SCHOOL GRADUATE ENLISTMENTS, CY 1973

Independent Variable	Coefficient	t-value
CANVASSERS (ln C/λ)	-914.0	-4.74
BLACK (BLACK · ln C/λ)	-232.0	-3.63
NETMIG (NETMIG · ln C/λ)	87.5	1.83
EDUC (EDUC · ln C/λ)	49.9	3.95
U (U · C/λ)	1496.0	4.34
PCI (PCI · ln C/λ)	-71.3	-4.04
QUOTA (ln QUOTA · ln C/λ)	93.7	3.77
	n = 41	
	R^2 = .91	
	F = 550.9	

Equation (4) can be evaluated for each NRD. When evaluated at the means of the explanatory variables (the "average" NRD), the marginal product of canvassers is only 2.20. That is, one additional canvasser yields somewhat more than two (2.20) additional school-eligible high-school graduate enlistments. For individual NRDs, the marginal product ranges from a low of 1.28 in the Richmond district to a high of only 2.76 in the Pittsburgh district. In short, canvassers appear to have very little effect on the number of enlistments, at the margin.[3]

This result may seem surprising, but there are good reasons to believe it is a correct one. First, the *average* product of canvassers is actually quite low. In CY 1973, the 41 NRDs had a total of 3,589 canvassers (including TEMACs) and school-eligible high-school graduate enlistments of non-prior-service males totaled 35,767. This implies an average product of only 9.96 (35,767/3,589) school-eligible high-school graduate enlistments per canvasser.[4] Given this low average product, our estimate of the marginal product does not seem an unlikely one. Second, our result is not particularly sensitive to the functional form we have chosen. Indeed, for the logit function, which produced fits that were nearly as good as those for the log-interaction form, the estimates of the marginal product were about *half* those given above.

[3] This result also holds for the marginal product of canvassers with respect to *total* enlistments. For total enlistments, the marginal product, evaluated at the means, is 4.05.

[4] The average product for *total* enlistments is only 18.46. These average products, however, understate the canvassers' workload. They also have responsibility for recruiting broken-service enlistments, Waves, reservists, and some other minor categories. With *all accessions* as the base, the average product in CY 1973 was 27.14.

For other forms that allowed the marginal product to vary across NRDs, the estimate of marginal product was always below 4.0.

The low marginal product of canvassers has several implications. First, because the marginal product of canvassers is so low, reallocating canvassers in order to equalize their marginal product across NRDs does not lead to a significantly greater number of enlistments.[5] Second, because their marginal product is so low, reducing the number of canvassers will not have a large effect on the number of enlistments or their average quality. This is a particularly important implication today, because Congress has cut the recruiting budgets of all services With a smaller recruiting force, however, the allocation of canvassers among NRDs may be more important than it was in CY 1973.

These results may also have implications about the functions of canvassers. Their low marginal product may imply that their "sales" or information-delivery function is a relatively unproductive one. This suggests that more efficient screening devices would free more time for information delivery and hence increase enlistments, or, alternatively, allow a smaller canvasser force to produce the same number of enlistments.

The results in Table 3 could be used for purposes other than determining the optimal allocation of canvassers. If the Recruiting Command decides to continue setting quotas, these results can be used to determine the "optimal" quota in each district, given the number of canvassers. In this context, an optimal quota would be one that not only represents a reasonable or fair goal, but one that is likely to maximize the quality of recruits.

The regression in Table 3 can also be used to evaluate the performance of the NRDs. Table 4 lists those NRDs for which actual enlistments exceeded or fell short of predicted enlistments by more than one standard error. It is tempting to view those NRDs with positive deviations as NRDs with "good" performance, and those with negative deviations as NRDs with "bad" performance. However, differences between actual and predicted enlistments can arise for several reasons. One of these is, of course, poor performance or productivity by the personnel in the district. However, such differences may also be due to misspecification of the regression model—such as the wrong functional form or omitted explanatory variables—or simply random fluctuations. For this reason, differences between actual and predicted

[5] Using the results in Table 3, we calculated the optimal number of canvassers in each district and then estimated the number of school-eligible high-school graduates this new distribution would have produced. With the actual distribution of canvassers in CY 1973, the regression of Table 3 predicted a total of 35,694 school-eligible high-school graduate enlistments. (The actual total was 35,767.) With canvassers allocated optimally, predicted enlistments were only 35,795, or an increase of only three-tenths of one percent.

Table 4

NRDs FOR WHICH PREDICTED SCHOOL-ELIGIBLE HIGH-SCHOOL GRADUATE ENLISTMENTS DIFFERED SIGNIFICANTLY FROM ACTUAL ENLISTMENTS

Deviations	
Positive	Negative
Denver	Buffalo
Milwaukee	Columbus
Montgomery, Ala.	Jacksonville
Washington, D.C.	Kansas City

enlistments should be thought of as evidence that the regression is not reflecting some influences on enlistments. For an NRD with a large deviation from predicted enlistments, a more detailed examination of the circumstances may reveal what is causing the deviation and may give the Recruiting Command important insights into the recruiting process.

CONCLUSIONS AND RECOMMENDATIONS

Two principal conclusions can be drawn from the preceding analysis. First, the primary determinant of the number of enlistments in an NRD is the characteristics of the population in the district. Second, the number of canvassers in a district has a small effect on enlistments, at the margin. The implication of these findings is that a modest reduction in the number of canvassers will not seriously affect the Navy's ability to recruit, in terms of either quantity or quality.

The low marginal effect of canvassers suggests that their information-delivery function is relatively unproductive and possibly even unimportant. If so, adoption of more efficient screening techniques would free canvassers' time for "selling" or would permit a smaller canvasser force.

We believe our work has several other implications for Recruiting Command policy. First, we have shown that quotas have a negative influence on enlistments and the effectiveness of canvassers. Thus we can only encourage the Recruiting Command in its search for a manageable alternative to setting quotas. If quota-setting is not abandoned, we recommend that the results of our work be used to set them in a manner that minimizes their undesirable effects.

Our work can also be used to allocate canvassers more efficiently. Although this would have little impact in the near term, a smaller canvasser force may make optimal allocation more important in future years. We have begun collecting data for the purpose of estimating Eq. (4) (and others, if necessary) for FY 1975. This exercise will be an important test of the validity of the results presented here. It should also allow us to improve the accuracy of our predictive equations.

We have also argued that our regression equations can be used, with caution, to evaluate the performance of individual NRDs. We recommend a careful investigation of the recruiting situation in any district whose enlistments are not accurately predicted by the regression equations. There may be important lessons to be learned from the experience of districts with below-average productivity as well as those with above-average productivity. Our analysis of FY 1975 data should facilitate this process, since FY 1975 experience may be more relevant for current policy. The Recruiting Command has made a number of policy changes since CY 1973 which may have significantly affected the productivity of individual NRDs and their canvassers.

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A MEDIA MIX TEST OF PAID RADIO ADVERTISING FOR ARMED SERVICES RECRUITMENT

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Prior to Congressional restrictions in FY 1972, the services had unrestricted access to both commercial television and radio; however, the Army was the only service that availed itself of these media. Primarily due to the lack of a detailed experimental design and to insufficient time within the paid broadcast media, the Army's results were not conclusive enough to justify a return to unrestricted paid broadcast avertising.

A more systematic and extensive paid radio advertising test involving all four services has since been conducted in 24 radio markets with 24 matched control markets. Effects during and after the test were measured. The test is described here, including (1) the method employed for selection of the radio test and control markets, (2) the experimental design developed to evaluate the effects on recruitment of paid radio advertising, and (3) the results of the test, comparing effects on intermediate recruitment variables such as image and attitude changes, increases in telephone inquiries and walk-in traffic, and discernible changes in the enlistment pattern among the target audience in the matched experimental and control markets. Finally, some of the marketing and statistical tools used by the larger consumer product companies, which were found applicable in the conduct of this test, are demonstrated.

INTRODUCTION

This paper describes an experiment designed to evaluate how well paid radio advertising can meet the advertising objectives of the military services in support of active force personnel procurement. The differences between a true experiment and the more common time series of historical data should be made clear at the outset. Webster defines an experiment as "a *trial* made to confirm or disprove something doubtful" and "an operation undertaken to discover some unknown principle or effect." An integral part of a controlled experiment involving a set of markets is the random assignment of individual markets to the test and control conditions. Time series analyses rely on multivariate techniques such as multiple regression analysis to untangle the effects of the many variables that interact in any real world situation. However, the assumptions of the regression model are rarely met. Moreover, time series analyses usually raise problems of multicollinearity, and if cross-sectional analysis is introduced to circumvent such problems, the criterion effects are frequently confounded with variables that are mismatched across markets with high levels of the variable of interest (i.e., test markets) and those with low or zero levels (i.e., control markets).

The central question in choices of media mix is responsiveness. We would like to be able to anticipate how markets are apt to respond to changes in the media mix. An experiment was felt to be the best tool to provide reasonable assurance of future outcomes. Although experiments are more expensive and more time-consuming than most alternative approaches, experimental results are almost always more valid and more reliable than the results of other methods.

This advertising experiment was executed during the fall of 1975, and the analysis of the test is still going on. This paper will report only those preliminary results that were available prior to the start of the conference.

BACKGROUND

Until the experiment, the Department of Defense (DoD) had not used paid broadcast advertising in support of military recruiting since 1971. The military services have developed their advertising media plans without access to either radio or television advertising except on a public service basis.

It is the policy of the DoD to seek Congressional approval to use paid broadcast advertising if it should prove to be cost effective from the point of view of the services' recruit advertising programs. The following statement is the official DoD position:

> The Department of Defense continues to favor a balanced media approach to recruit advertising, free from prohibitions with respect to media options. The Department of Defense is

> analyzing the relative effectiveness of paid broadcast advertising in support of the All Volunteer Force. The results of this analysis, should paid broadcast advertising prove cost effective, will be used as rationale in requesting the consent of Congress for all components of the Defense Department to employ paid broadcast recruit advertising if they so desire. Such Congressional consent would enable each component to develop media plans without specific media prohibitions.[1]

To date, the analysis referred to in the above statement has involved a media study conducted by the Office of the Secretary of Defense (OSD) and the simultaneous test of paid radio.

The OSD media study evaluated the cost efficiency of including paid broadcasts in service advertising media schedules in terms of target audience delivery (e.g., target audience reach and frequency). The media study concluded that the use of paid broadcast (radio and/or television) advertising could have a positive effect on service advertising budgets in either of two directions:

1. Greater target audience reach and frequency for the same budgets.
2. Similar target audience reach and frequency with lower budget levels.

Audience delivery efficiency, however, is a necessary but not sufficient indicator of advertising media effectiveness. Effectiveness is also dependent upon the inherent ability of the medium to convey a message plus the specific creative execution used in the advertising.

OBJECTIVES OF THE TEST

General Purposes

The primary objective of the research was to measure the ability of paid radio advertising to contribute to the recruitment efforts of the armed services. Since media efforts presently exclude paid radio, the central question was how radio would perform relative to present media use when gross impressions[2] on young people between the ages of 17 and 24 are equalized for a media plan containing a mix of radio and other media and for a media plan containing only other media. We

[1] Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs) memorandum to Assistant Secretaries of the Military Departments (M&RA), 31 March 1975.

[2] The term "gross impressions" refers to the sum total of exposures to the full list of media used during a specified period of time.

also hoped to gain a considerable amount of insight into *how* radio might best be used, should it prove to be an effective medium.

The objectives of the test were modest. However, given the generally negative experience of media tests, we reasoned that it would be unwise to be more ambitious in the first experiment. It was hoped that one solid, clean experience would lay the groundwork for future work with controlled experiments.

Specific Performance Criteria

There are a large number of ways in which the effectiveness of advertising can be measured. The most important one is the desired end result—in this case, accessions. However, enlistment effect is probably also the most difficult criterion to influence. Advertising, when it is successful, operates in a variety of ways.

One potential effect, often obtained in the early stages of a campaign, is a change in public awareness of the service being advertised. A second possible effect is a change in the amount and nature of the information being communicated. Third, if the information communicated interacts favorably with the value systems and predisposition of the person exposed to the advertising, that person's attitude toward joining a service may change in a positive direction. And finally, the exposed person may take some specific *action* toward enlistment, such as making an inquiry by mail, by telephone, or in person. He may even take an enlistment qualification test.

There are no clear-cut rules as to which of these criteria are apt to be affected by a given campaign, or in what sequence they are likely to be affected. The safest procedure is to measure them all, and that is what we did. We measured:

- Contracts for accession.
- Inquiries by mail, telephone, and in person (at both national and local levels).
- Predisposition toward joining a service.
- Awareness and knowledge of specific programs and benefits offered by individual services.
- Awareness of armed forces advertising.

This list is arranged in order of presumed importance. In other words, the most important effect that could possibly occur would be a direct increase in contracts for accession. Next would be people taking actions that might be precursors to joining a service. Then come favorable attitudes, knowledge, and awareness of advertising—in that order. Interestingly, the more important the criterion, the more difficult it is to change it through advertising. The easiest measure to change is advertising awareness, and the hardest is contracts for accession.

DESIGN OF THE TEST

Philosophy and Overall Design

In designing the test, we used the principles of experimental design developed originally for tightly controlled agricultural experiments. These allow the researcher to sort out the effects of the variable of interest (in this case, our two types of media schedules) from the effects of the many other variables that inevitably intrude on a test of this sort and mask the effects of the key variable. In real world experiments, some compromises are inevitably required because of budgetary and time limitations. This section spells out the nature of those compromises.

The Unit of Analysis

Markets were chosen as appropriate test units because they were the smallest geographical unit within which media—in particular, radio—could be manipulated efficiently. After discussions with service advertising media planners, we decided that markets would be defined as SMSAs (Standard Metropolitan Statistical Areas) because many of the data required for matching and for evaluative purposes were collected using that particular form of market definition.

Combinations of Services to be Represented

Further discussions with service advertising managers indicated that there would be few instances in which all four services would be advertised in the same markets simultaneously. At the same time, pairs and trios of services did seem likely, and we hypothesized that there might well be interaction effects between the combinations of services doing the advertising in a particular market. Accordingly, we compromised on a design that allowed us to measure two of the many conditions that might result should the services be permitted to use paid radio advertising: a service advertising alone, and a service advertising with two other services. We hoped to be able to make some reasonable interpolations for the missing conditions.

The Experimental Design

One of the principal tradeoffs in selecting test and control markets is that between projectability and the precision of market matching. Markets can be dispersed geographically, which aids projectability, or they can be concentrated in clusters, which aids matching. Complicating the situation in this study is the necessity of representing each of the four services alone and in combination with the other services.

The design selected represented a compromise. It required eight triads of matched markets, as shown in Table 1. Within each triad, two markets were to serve as test markets for one of the test conditions, and one was to serve as a control. Test markets were so named because some form of paid radio was used in them. Control markets maintained a nonradio schedule. The use of a single control market in each triad was a concession to cost. Also, we were particularly concerned about having a large enough sample of markets for the new test condition (occasionally in the course of a test like this, markets have to be dropped for one reason or another, e.g., natural disasters). Moreover, we felt that we might, if necessary, make some of the control markets do double duty against test conditions in triads outside their own.

Table 1

RESEARCH DESIGN

Market Triad	Test 1	Test 2	Control
Single Advertiser			
Air Force	Bowling Green	Boise	Casper
Army	Columbus, Ohio	Atlanta	Omaha
Marine Corps	Augusta	Dothan	Charleston, S.C.
Navy	Lansing	Knoxville	Binghamton
Three-Service Simultaneous Advertiser			
AF/A/MC	Denver	Kansas City	Albany
A/MC/N	Louisville	Seattle	Portland
MC/N/AF	Valdosta	Baton Rouge	Shreveport
N/AF/A	Altoona	Spokane	Yakima

Market Matching

The history of media testing is not very encouraging to people who hope to conduct such tests. Typically, the effects of extraneous variables overwhelm the effects of the test variables and results cannot be interpreted. To hold this risk to the lowest possible levels, we took great care in matching test and control markets before the beginning of the test.

To begin with, a list of 175 possible SMSAs was compiled. The largest 155 were markets for which Arbitron ratings (a standard radio source) were available. Ratings for larger markets are compiled from consumer diaries, but we also included a set of 20 smaller markets to provide some representation for that particular size bracket. The list was then "purified" by excluding markets considered too large for testing purposes, markets with special media problems, and markets with large military bases.

For the surviving 138 markets, we ran a regression to identify variables associated with quality accessions (male high-school graduates in Mental Categories I, II, and III divided by Qualified Military Availables (QMA)), clustered markets into groups with similar profiles across the relevant variables, randomly chose starting point markets within clusters, developed triads around each market chosen, and randomly assigned markets within triads to the test and control conditions. The following equation shows the regression coefficients obtained from the first step in this process:

$$\text{Accessions/QMA} = -.00001 + .5772\ (\text{recruiters/QMA})$$
$$-.7814\ (\text{QMA}) - .2031\ (\%\ \text{working women})$$
$$-.1857\ (\%\ \text{owner-occupied housing}) + .1498\ (\%\ \text{black})$$

$$\text{Multiple } R = .5532$$

However, even the best pre-test matching procedure is subject to some risk. With bad luck, the random aspects of the selection process can cause unbalanced test and control groups. Moreover, markets that appear to be matched on one basis before the test begins may appear out of balance when further data become available. Thus, to guard against random mismatches, an extensive post-analysis was made of the base period differences between the test and control markets.

An examination of 148 variables, 21 of which were designated as criterion measures and the remainder as covariates, showed that very few of the criterion measures were mismatched (fewer than would be expected by chance). Results were similar for the covariates. Moreover, none of the latter group bore a very strong relationship to any of the criterion measures. Table 2 shows a portion of the covariate data for the Air Force.

Sources of Information Used in the Investigation

Five major sources of information were used in the course of the investigation.

Table 2

AIR FORCE: ARMED FORCES COVARIATE DATA, TEST PERIOD

Item	Markets	
	Test	Control
Unemployment rate (10/1/65)	6.75	7.38
Wage rate (10/1/75)	199.64	220.26
No. of stations in market divided by QMA	.02	.02
Total number of station open hours divided by QMA	.20	.15
No. of males walking past offices or signs during four sample periods divided by QMA	.01	.01
Quota 9-12/75/QMA	.49	.45
Percent achieved 9-12/75	108.62	105.00
Age		
Percent 22 and older	18.84	22.59
Percent 17 and 18	42.11	39.29
Schooling		
Percent high school graduate	41.28	37.32
Percent 11th grade or less	35.99	36.03
Mean high school grade level	2.20	2.23
Percent in college-preparatory	54.77	56.98
Percent in industrial/vocational	30.30	25.72
Mean math level	2.43	2.43
Percent passing electricity/electronics courses	20.39	16.68
Percent with high school military training	4.58	8.95
Car, Radio Ownership		
Percent owning car	70.90	71.90
Percent with working car radio	64.89	66.11
Percent with working portable battery radio	57.88	58.16
Ethnic		
Percent Hispanic (Cuban, Mexican, Puerto Rican, Spanish)	1.87	3.44
Percent black	10.28	7.62
Percent nonwhite	14.82	13.79
Household Type		
Percent with parents or guardian at home	72.08	68.92
Percent in own home/household head	20.00	21.99
Percent in dorm or other college building	?.20	1.99

- A telephone survey of consumers (three waves of 1,800 interviews each of men aged 17 to 24 and with a probability sample of the 24 markets).
- An audit of recruiting stations (all stations in the 24 markets were visited, and a follow-up telephone audit was made of the largest stations).
- Service data on inquiries and contracts for accession.
- A databank based on secondary sources.
- Service advertising agencies.

Highlights of the procedures used in gathering information from each of these sources are covered in the following paragraphs.

The Consumer Survey

The role of the consumer survey was to provide information on the criterion measures relating to actions taken (e.g., inquiries recalled), predisposition toward the services, knowledge of their programs, and awareness of armed forces advertising. In addition, data on a host of covariates were gathered.

The general research design called for monitoring each market before the beginning of the actual test in order to establish a normal or "base" level for that market. During the test period, the changes of each market from its base were monitored, and the changes in the test markets were compared with those of the control markets. In a perfect test, that is all that would be required. However, in the real world, many variables beyond those we know we are varying can affect our criterion measures. Fortunately, if we are able to measure them, we are also able to make some statistical adjustments for their effects. These variables are called covariates, because they covary with the measures of direct interest to us (our criterion measures).

To give ourselves the greatest possible chance of a meaningful analysis, we attempted to measure *every* covariate that we thought might conceivably influence our criteria. Questioning covered a variety of areas, including:

- The probability of choosing various career alternatives, including enlistment in each armed service.
- Attitudes toward each service and toward the military in general.
- Awareness and knowledge of recruitment programs and the communications objectives of individual services.
- Awareness and recall of advertising copy.
- Recall of contacts made with or inquiries made of services or recruiting personnel.

- Media habits.
- Past family associations with the armed services.
- School grades and types of educational programs enrolled in.
- Demographic data such as age, education, occupation, marital status, income, and residential status.

The survey itself was a three-wave, before/after telephone survey conducted in test and control markets among a probability sample of men 17 to 24 years of age with less than three years of college and no previous military involvement. The first, or base, wave was conducted just before the start of test advertising (between August 21 and September 7, 1975). A second wave was conducted at the midpoint of the test period (between October 11 and October 25, 1975), and a third at its close (between December 6 and December 19, 1975).

The Audit of Recruiting Stations

The primary purpose of the audit of recruiting stations was to gather data on the volume of local inquiries received by mail, by telephone, and in person. However, we felt that these also might be affected by covariates and that the nature of the recruiting stations might in turn have an effect upon the rate of accessions and other performance criteria. Accordingly, we once again obtained information on a large number of potential covariates. These included:

- Number of stations.
- Total size of staff.
- Number of production recruiters.
- Number present in the office at the time of an audit of the recruiting station.
- Average grade of production recruiters.
- Number of hours stations are open.
- The extent to which stations are in central cities.
- Whether they are in retail areas or residential areas.
- Whether they are in nonwhite areas.
- Whether they are in storefronts, shopping centers, or malls.
- Whether they are at street level.
- How visible they are.
- Whether other services have stations in the immediate area.
- The number of telephone lines and instruments.
- Convenience of parking facilities.
- Foot traffic past offices during sample periods.

Still another factor that we thought might have a bearing on the performance of our criteria was the status of individual stations relative to their quotas. For example, stations that are short of their quotas may, in the short term, have higher production records than those that have comfortably exceeded them.

The foregoing data were obtained in this manner: Each of the recruiting stations in the 24 test and control markets was visited and information was gathered on the characteristics of the station, its location, its personnel, and its methods of operation. In addition, a special telephone audit was made of a representative sample of high-traffic stations. These accounted for more than 70 percent of all inquiries. Recruiters were asked to keep track of unsolicited inquiries by mail or in person during a random time sample of the hours during which the stations are open. About 30 seven-hour days, or about 200 hours in total, were audited in each market. A typical station was audited about 40 hours during the base period and about 80 hours during the test period.

Service Data on Inquiries and Accessions

Inquiries are received at national centers as well as at individual recruiting stations. Inquiries received at the national centers but originating in test or control markets were tabulated as part of the input data and represent one of the criterion measures.

Similarly, DoD data on accessions were compiled for all test and control markets for the base and test periods, and they represent another criterion measure.

Secondary Sources

Databanks. The data mentioned earlier in conjunction with the marketing matching process also have potential value as covariate data. They contain variables such as:

- Unemployment rates.
- Wage rates.
- Qualified Military Availables.
- Population.
- Percent of the population that is black.
- Percent working women.
- Percent owner-occupied dwelling units.
- Demographic characteristics of the market.

The data were gathered from several sources, primarily from a databank of economic and demographic information compiled largely from Department of Commerce records.

Service Advertising Agencies. Each service advertising agency provided detailed information on media delivery in each of the 24 markets. These, of course, are likely to be important covariates. They include:

- "Reach" obtained in each market (the proportion of people in the target group exposed to one or more messages).
- "Frequency" obtained in each market (the average number of exposures per exposed person in the target audience).
- Gross impressions obtained (the total number of exposures).
- Separate data for Sunday Supplements, outdoor advertising, and magazines.
- An audit of Public Service announcements run on radio or TV.

ANALYSIS AND PRELIMINARY RESULTS

The design used makes possible the evaluation of test results at several different levels of generality. At the most general level, the performance of our criteria in all 16 test markets can be contrasted with that of the eight control markets to provide measures of the effects of paid radio for the total DoD. Second, the performance of each individual service in its eight markets can be compared with its four control markets. Third, interaction effects can be estimated by contrasting what happens when a service advertises alone with what happens when it advertises with other services.

Our specific plan of analysis involved detailing of 21 criterion variables, including contracts for accession; local inquiries (total, phone, walk-in, and first male contact); national inquiries (total, phone, and mail); recalled actions (read direct mail, responded to mailing, made toll-free call, sent in coupon, and total of mail plus toll-free plus coupon); attitude measures (in planning for next few years, some possibility of joining, very or fairly likely to join, linear probability, log probability, and rating general idea of enlistment for others); advertising awareness; and radio advertising awareness. All criterion measures are available on a service-specific basis.

The rationale for the statistical analysis plan called for factor analysis by service of the 21 criterion measures to produce a reduced set of underlying variables, if possible, for further analysis. Next, the large number of covariates was too large for the available degrees of freedom afforded by the experimental design. Therefore, it was necessary to screen them down by correlating them with the factor-analyzed criterion measures. Covariates that are both mismatched across service test and control markets and significantly related to the reduced set of criterion measures across all four services were to be used to adjust the data for lack of experimental control. Analysis of variance would then be conducted to determine if any observed differences between test and control markets on the reduced set of criterion measures were statistically significant.

Table 3 summarizes preliminary test results for the 21 criterion variables. Since significance tests had not yet been applied at this writing, these preliminary results show direction of change only and cannot be assumed to show real changes. A plus in Table 3 indicates that a criterion measure shows a positive difference when control

Table 3

CRITERION MEASURE CHANGES

Criterion Variable	Air Force	Army	Marine Corps	Navy
Contracts for Accession	+	+	+	-
Local Inquiries				
Total	+	+	+	+
Phone	+	+	+	+
Walk-in	+	+	+	+
First male applicant	+	+	+	+
National Inquiries				
Total	+	+	-	+
Phone	-	+	-	+
Mail	+	+	-	+
Recalled Actions				
Read direct mail	+	+	+	-
Responded to mailing	-	-	+	-
Called toll free no.	-	+	-	+
Sent in coupon	-	-	+	-
Mail + toll free + coupon	-	-	+	-
Attitudes				
In plans for next few years	-	-	-	-
Some possibility of joining	-	-	-	-
Very/fairly likely to join	-	-	-	-
Probability (linear)	-	-	-	-
Probability (log)	-	-	-	-
Idea of enlistment	+	+	+	+
Awareness				
Of military advertising	+	+	+	+
Of radio advertising	+	+	+	+

+ = Favors radio markets.
− = Favors control markets.

market values (test minus base periods) are subtracted from radio market values (test minus base periods). In other words, a plus shows the radio advertising media mix outperforming the control market media mix on that particular criterion.

CONCLUSION

It should be noted that this radio experiment has been undertaken as one component of a larger analysis addressing the issue of the effectiveness of paid broadcast recruiting advertising. The information output of this analysis and research process will be used by the DoD to help determine advertising policy within the DoD and to seek Congressional consent for paid broadcast use if it proves cost effective.

The specific analytic plan outlined above for this paid radio study is intended to aid DoD policymakers in evaluating specific policy issues of access to paid broadcasting. Although micromanagement issues concerning advertising resource allocation are not the primary purpose of this study, a great deal of follow-on diagnostic analysis is possible using this experimental data base. These data will likely be used by the individual military services for micromanagement purposes.

This particular media study should serve to illustrate the demands on management and researchers alike required to measure recruiting advertising effectiveness. Multivariate experimental design (quasi-experimental at best) is the research tool that can accomplish this but it is demanding, complex, time-consuming, and costly. The study described here has a very narrow objective. As experimentation is used for expanded objectives such as determining tradeoffs between recruiters and advertising or among recruiters, advertising, and enlistment bonuses, the demands on management and the researcher will become much greater.

Measurement of advertising effectiveness for recruiting is a challenging task in and of itself. DoD managers should attempt to improve his understanding of advertising productivity through the judicious use of experimentation to provide data for modeling the relationships between advertising and quality accession effects. Experimentation can be combined with tracking (descriptive studies) of such intermediate criteria as awareness, attitude, and inquiries. The tracking results can then be used to estimate accession effects based on the models developed through experimentation.

A MODEL FOR ESTIMATING PREMATURE LOSSES[1]

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Recruits who joined the Navy during the first year of the all-volunteer force were tracked through their first year of service. Background and selection test data are related to premature discharges from this cohort, and estimated chances of surviving the first year of service are presented in a table. The table can be used for planning recruiting policy and screening applicants for enlistment.

BACKGROUND

Navy concern about early losses of first-term enlistees led to this study. Nearly 30 percent of the enlistees in 1970 had been prematurely discharged by the end of 1974, and projections for subsequent years were even higher [1,2]. The Navy was concerned not only about the effects of the losses on training plans and fleet readiness, but also about the dollar costs. The average cost of getting one recruit to his first duty station following graduation from recruit training exceeded $3,000 in FY 1975.

Consequently, the goal of this study was to develop a model of losses during the first year of service that could be used to evaluate recruiting policy changes and improve the screening of applicants for enlistment.

[1] The ideas expressed in this paper are those of the author. They do not necessarily represent the views of either the Center for Naval Analyses, the United States Navy, or any other sponsoring agency.

ENLISTED LOSS MODELING

In planning recruiting policy, the Navy uses a four-way combination of educational level and mental ability in conjunction with the number of recruits needed:

	High-School Graduate	Non-High-School Graduate
School-eligible	A	B
Non-school-eligible . . .	C	D

School eligibles are individuals with above-average mental ability as measured by the Navy Basic Test Battery used for selection of entrants into the Navy and into technical training.

Overall recruiting goals are set, then the desired ratio of recruits in the lettered quality categories (for example, 4A plus B for each C or D) or the desired percentages of school eligibles and high-school graduates are specified. In carrying out these policies, recruiters use an odds for effectiveness (OFE) table that indicates the chances in 100 that an applicant will complete a four-year enlistment. The table is based on education, mental ability, and expulsions and suspensions from school. It was developed in the early 1960s on a sample of recruits [3] and was modified recently to eliminate data on arrests for non-traffic offenses that recruiters had difficulty in obtaining from the courts. The Recruiting Command sets minimum odds for applicant qualification also.

Today, readily available background information can be related to survival status for large cohorts of enlistees in a model that is useful both for planning recruiting policy and applicant screening.

Cohort and Data

The cohort for this study contained 66,680 males, almost the entire input of USN non-prior-service recruits with an active data base in CY 1973. By this time, the effects of the draft on recruiting had diminished; we estimated that only 1,539 of the men were draft-motivated.

Background data on these recruits came from the SCAT tape created from data reported to the Armed Forces Entrance and Examining Stations (AFEES) by the Navy. They included date of birth, education, AFQT score and mental group, term and program of enlistment, race, dependents, and recruiting district. Reasons for discharge during recruit training came from the three Navy Recruit Training Commands (RTC). Enlisted Master Records (EMR) and Loss Tapes from the Bureau of Naval Personnel enabled us to track the cohort through the first year of service and provided additional data on Basic Test Battery (BTB) scores, loss codes, and service history. Mental groups were recalculated from scores on the BTB to conform with current testing policy. Formerly, a short version of the battery was administered to applicants; today, the full-length battery is given in the field.

Losses and Reasons

Nine percent of the cohort were prematurely discharged during recruit training, and 17 percent were discharged during the first year of service.[a] Although reasons for losses are not precisely applied, Table 1 shows that character and behavior disorders and inaptitude/apathy were cited in over half of the discharges. Nearly half of these discharges occurred during recruit training. Erroneous and fraudulent enlistments were cited in over one-fourth of the discharges, and 90 percent of these discharges occurred in recruit training.

Table 1

FIRST-YEAR LOSSES BY REASON AND PERCENTAGE INCURRED DURING RECRUIT TRAINING

Reason	Percent of 1st Year Attrition		Percent in RTC
Character and behavior disorders	37.6	52.3	45
Inaptitude/apathy	14.7		49
Enlisted in error	16.3	27.1	91
Fraudulent enlistment	10.8		89
Physical disability	9.5		36
Court involvement	6.6		0
Alcohol/drug-related	1.8		0
EAOS related	1.8		17
Hardship	0.9		3
Total	100		52
Number	11,498		6,040

Differences were observed among the three RTCs. San Diego had 35 percent of the recruit input but only 29 percent of the losses. In contrast, Great Lakes had 36 percent of the input but 44 percent of the

[a] These percentages are underestimates of the actual rates because of unmatched accession and attrition records due to incorrect Social Security numbers. The Recruiting Command has estimated that 15 to 20 percent of the records are unmatched at the recruit training stage. Since mismatches are probably a random sample from the cohort, the results of the analyses should not be biased by their absence.

losses. Losses due to medical reasons were highest at Great Lakes (43 percent) and lowest at Orlando (21 percent). However, losses due to character and behavior disorders were highest by far at Orlando (62 percent) and lowest at Great Lakes (12 percent). Conversely, losses due to fraudulent enlistment—drug use—were highest at Great Lakes (25 percent) and lowest at Orlando (12 percent). We could not be sure that some of the reasons for discharge meant the same thing or were used consistently at the different RTCs. Consequently, we pooled them.

By the end of the first year of service, Great Lakes had maintained its disproportionate share of losses, while the other two RTCs' losses were proportionate to their inputs. However, some of these differences were due to the quality mix of recruit inputs. If the first-year loss rates were adjusted by mental group and educational level, the rate for Great Lakes would drop 2 percentage points, San Diego would increase by the same amount, and Orlando would be unchanged.

Overall, the fact that the short BTB battery used in the field overestimated the mental group of non-school eligibles, coupled with larger proportions of non-high-school graduate accessions, probably was responsible for much of the increase in premature separations beginning in FY 1973. Another contributor to this situation was a growing tendency on the Navy's part to discharge problem sailors as soon as possible to minimize disciplinary, administrative, and supervisory burdens.

Loss Model

The explanatory variables selected for use in the loss model (biographical and mental test variables) were available early on all prospective recruits, were outside the control of the Navy (as opposed to the case of special training programs, medical waivers, and assignments to RTCs), and applied to a sufficiently large number of individuals that sampling error would not be excessive.

Since the use of a loss/survive dependent variable would cause statistical problems in regression analysis [4,5], and since the cohort was so large, recruits were grouped by combinations of variables. The levels of these variables were defined in dummy form for both qualitative and quantitative measures. Loss rates were then calculated for each group of recruits. An example of a group would be recruits in Mental Category II who were high-school graduates, 18 or 19 years old, unmarried, and from a racial minority. This process resulted in 180 possible groups, of which 148 contained data. These 148 groups became the units of observation for the regression analyses of dummy variables on loss rates.

The loss model hypothesized that the probability of attrition during the first year of service for the i^{th} group of male recruits, P_i, was a function of:

LT12ED — less than high-school graduation
*12ED — high-school graduation
GT12ED — more than high-school graduation
MGI — Mental Category percentiles 93 and above
MGII — Mental Category percentiles 65 to 92
*MGIIIU — Mental Category percentiles 49 to 64
MGIIIL — Mental Category percentiles 31 to 48
MGIVU — Mental Category percentiles 30 and below
AGE17 — age 17
*AGE18−19 — ages 18 and 19
AGE20+ — age 20 or older
*MAJ — racial majority
MIN — racial minority
PDEPS — primary dependents (wife, children)
*NDEPS — no primary dependents

then

$$P_i = a + \sum_{j=1}^{k} \beta_j X_{ij} + U_i$$

where a is an intercept that subsumes one dummy variable of each set (starred in the list above), U_i is the error term, the β_is represent the coefficients to be estimated, and the Xs are the dummy variables (not starred in the list above). Using these variables and estimates of a and the βs found by multiple regression analysis in the model, we were able to predict the probability, P_i, of any individual (with a given set of characteristics) attriting during the first year of service.

For simplicity, we first assumed the linear functional form given above. But since the loss rate is a number lying between 0 and 1, we also estimated regressions using a logit transformation of the dependent variable [5,6]:

$$\ln \frac{P_i}{1-P_i} = a + \sum_{j=1}^{k} \beta_j K_{ij} + z_i$$

where ln indicates the natural logarithm, the X_is are the independent variables, and z_i is the error term.

Weighted ordinary least-squares regressions for the linear and logit specifications were run. The weights for the groups were, respectively, $\sqrt{n/pq}$ and $\sqrt{npq}$, where n is the number of recruits in a group, p is the proportion of losses, and q is the proportion of survivors [7]. Where there were no recruits for a particular combination of independent variables, that combination was ignored. Where $P_i = 0$, the loss rate was taken as $1/2n_i$. Where $P_i = 1$, the rate was taken as $1 - (1/2n_i)$ [7].

Interaction effects among the dummy independent variables were explored with a computer program that identified optimal configurations of the variables [8]. The groups were split so as to maximize the between sum of squares for the categories of each independent variable while minimizing the within-groups sum of squares. All possible splits are considered in the process. A total of 22 simple and complex significant interactions were identified and incorporated in the logit regression model. Although three of them proved to be significant at the 1 percent level, their practical contribution to explaining the variance of the dependent variable was negligible. Consequently, the regression models were run without interaction terms in the final analysis.

The results of these final analyses are contained in Table 2, where the variables are listed in order of their importance in explaining the

Table 2

WEIGHTED REGRESSION RESULTS FOR LINEAR AND LOGIT FIRST-YEAR LOSS MODELS: 148 GROUPS

Explanatory Variable	Linear			Logit		
	Coefficient	t	r_p[a]	Coefficient	t	r_p[a]
Constant	.118	26.89	--	-1.976	-57.35	--
LT 12 ED	.111	19.03	.852	.701	21.20	.875
MG IV	.100	13.44	.754	.597	14.23	.772
MG I	-.078	-10.85	-.680	-.989	-8.37	-.582
MG IIIL	.052	7.91	.560	.365	8.85	.603
AGE 20	.032	5.43	.421	.280	6.43	.482
MG II	-.026	-5.28	-.411	-.254	-6.22	-.469
MIN	-.034	-4.89	-.386	-.119	-2.64	-.220
GT 12 ED	-.031	-4.49	-.358	-.314	-4.42	-.353
DEPS	.038	4.36	.349	.389	6.95	.510
AGE 17	.015	2.89	.240	.093	2.76	.330
R	.961			.964		
R^2	.924			.929		
F (10,137)	16.760			17.865		
Standard error	.023			.170		

[a]The correlation of the explanatory variable with the dependent when the other explanatory variables are held constant.

loss rates in the linear model. Because the results for the two models are very similar, the simpler linear model was chosen for use.

Chances of Surviving the First Year of Service

The chances out of 100 of surviving the first year of service are shown for majority and minority recruits in Table 3. They were calculated by subtracting the predicted loss rates from 100. The standard error in estimating loss or survival rates is 2 percentage points. Thus, actual rates can be expected to fall in the interval of the predicted rate ±2 percentage points 2 out of 3 times, and ±4 percentage points 95 out of 100 times.

Policy Guidance. Predicted first-year survival rates for the lettered quality categories used by the Recruiting Command are shown in Table 4. From this table it can be seen that a recruiting policy that excludes applicants in the D category would have eliminated 28 percent of the minority recruits in CY 1973, compared to only 16 percent of the majority recruits. Recruiting policy that limits the C category to 1 for each 4 A+B (school-eligible) applicants also would have severely restricted minority recruiting in CY 1973, since nearly half of the minority recruits were in the C category.

Interestingly enough, the survival rate of the C category was about 3 percentage points higher than that of the B category for both majority and minority recruits. Further, the survival rate of minorities exceeds that of the majority by about 2 percentage points in each category. The overall loss rate for minorities was higher than that for majority recruits, but only because of the disproportionately large percentage of minorities in the C and D categories (77 percent compared to 31 percent of the majority recruits).

With respect to school eligibility (A and B categories), it is more difficult for minority recruits to qualify for Navy schools because they score, on the average, 7 to 8 points lower on the BTB tests used to qualify candidates for school [9].

As an example of how the predicted survival rates can be used, consider the FY 1975 data shown by quality categories in Table 5. The predicted survivors after one year of service are 84 percent of the majority recruits and 85 percent of the minority recruits. In this cohort, elimination of the D category would have reduced both types of inputs by about 10 percent. The ratio of school eligibles to non-school-eligible high-school graduates (A+B:C) was 9.6 to 1 for the majority recruits and 3.5 to 1 for the minority recruits.

The predicted survival rates for the four quality categories can be applied to any input to evaluate numbers of survivors (or losses) expected under alternative policies for majority and minority personnel.

Tabie 3

CHANCES OF SURVIVING THE FIRST YEAR OF SERVICE[a]

		Majority						Minority					
Years of Education:		>12	12	<12	>12	12	<12	>12	12	<12	>12	12	<12
MG	Age	No Dependents			Dependents			No Dependents			Dependents		
I	18-19	99	96	85	95	92	81	99	99	88	98	95	84
	17	97	94	83	93	90	79	99	98	87	97	94	83
	20+	96	92	81	92	89	78	99	96	85	95	92	83
II	18-19	94	91	80	90	87	76	97	94	83	93	90	79
	17	92	89	78	89	85	74	96	94	82	92	90	78
	20+	91	88	76	87	84	73	94	91	80	90	87	76
IIIU	18-19	91	88	77	87	84	73	95	92	80	91	88	77
	17	90	87	76	86	83	72	93	90	79	89	86	75
	20+	88	85	74	84	81	70	91	88	77	88	85	73
IIIL	18-19	86	83	72	82	79	68	89	86	75	86	83	71
	17	85	81	70	81	78	67	88	85	74	84	81	70
	20+	83	80	69	79	76	65	86	83	72	82	79	68
IV	18-19	81	78	67	77	74	63	85	82	70	81	78	67
	17	80	77	66	76	73	62	83	80	69	79	76	65
	20+	79	75	64	74	71	60	81	78	67	78	75	63

[a]Standard error of estimate equals ±2 percentage points.

Table 4

PREDICTED CHANCES OF SURVIVING THE FIRST YEAR OF SERVICE BY CNRC QUALITY CATEGORIES

Quality Category	Majority % Input	Majority Predicted Survival Rate	Minority % Input	Minority Predicted Survival Rate
A	56.4	89.6	18.6	91.6
B	12.6	76.8	4.3	79.7
C	15.2	80.2	49.4	82.3
D	15.8	68.2	27.6	70.7
A + B	69.0	87.3	22.9	89.4
A + B + C	84.2	86.0	72.4	84.6
Total	100.0	83.2	100.0	80.7

Table 5

PREDICTED FIRST-YEAR SURVIVORS FROM FY 1975 COHORT BY CNRC QUALITY CATEGORIES[a]

Quality Category	Majority Input	Majority % Input	Majority Predicted Survivors[b]	Minority Input	Minority % Input	Minority Predicted Survivors[b]
A	41,302	61.9	37,028	5,363	49.3	4,915
B	13,397	20.1	10,292	2,246	20.7	1,790
C	5,735	8.6	4,601	2,197	20.2	1,809
D	6,291	9.4	4,293	1,067	9.8	754
A + B + C	60,434	90.6	51,920→85.9%	9,806	90.2	8,514→86.8%
Total	66,725	100.0	56,213→84.2%	10,873	100.0	9,268→85.2%
A + B: C		9.6 to 1			3.5 to 1	

[a]Using the rates given in Table 4 times the Input.

[b]Input figures from CNRC Distribution of Non-Prior-Service Male Recruits (QUEBECS), 1 July 1974 — 30 June 1975.

The standard error of estimate should be kept in mind when interpreting the predictions.

Applicant Screening. The chances of surviving the first year of service can easily be used by recruiters in evaluating applicants. Based on readily available information, Table 3 can be entered quickly to find the chances out of 100 that a prospect would still be in the Navy one year after he went on active duty.

Further, the Recruiting Command could also set limits to the probability that a recruit will not survive the first year in refining recruiting policy, subject to the supply of applicants and the requirements of the Navy.

CONCLUSIONS

Because of its currency, comprehensiveness, and ease of application, the model developed in this study merits use (1) in establishing and modifying recruiting policy and (2) as a replacement for the outdated odds-for-effectiveness table used in screening applicants for enlistment.

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Part III

PERSONNEL MANAGEMENT

MEASURING ON-THE-JOB PERFORMANCE IN MILITARY OCCUPATIONS

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Human-capital theory has been applied to the problem of estimating the level of the net contributions of first-term personnel to military effectiveness. The effects of individuals' personal attributes and military training on their net contribution are also estimated, for fifty specialties in the three major service branches. The study design is described (including estimating methodology, criteria for the selection of specialties and individuals to be included in the study, and data collection procedures). In addition, results of the initial analyses of three specialties are presented.

INTRODUCTION

Almost all new entrants to the military attend a formal course of instruction in the skills required in their military occupational specialties. About 320,000 of the 350,000 enlisted personnel joining the military in FY 1976 have received such training. Since initial specialty training involves about 80,000 man-years of the trainees' time and will cost about $2 billion,[1] the importance of conducting it efficiently is obvious. Even small improvements in efficiency can result in substantial, recurring savings.

A great deal of research has been devoted to improving "technical efficiency." Technical efficiency involves selecting the mix of cur-

[1] These estimates are derived from *Military Manpower Training Report for FY 1976*, Office of the Assistant Secretary of Defense (Manpower and Reserve Affairs), Washington, D.C., March 1975.

riculum, instructors, teaching aids, etc., that produces course graduates with a given level of proficiency at the lowest cost. There are, however, a great number of technically efficient courses in a given specialty, each one producing a different level of proficiency in course graduates. The problem of selecting among these courses (and corresponding levels of proficiency) involves another aspect of training efficiency—economic efficiency. On one hand, it is technically possible to teach all the skills required in a military specialty during initial specialty training. On the other hand, since almost any set of job skills *could* be taught entirely on the job, formal specialty training could be totally discontinued without losing the ability to maintain an effective military force. The reasons for having formal specialty training are economic rather than technological. To evaluate the optimal amount of formal training, it is necessary to compare the benefits of additional training with its costs. The costs of formal training (faculty and student salaries, supplies, etc.) are obvious. The returns are less obvious because they take the form of improvements in trainees' on-the-job performance. Economic efficiency in formal training is attained when the last dollar spent on increasing the amount of formal training increases the benefits received after training by one dollar.

To analyze the economic efficiency of training, a method of measuring the effects of initial specialty training on graduates' on-the-job performance is needed. The difficulty of developing a satisfactory measure has been the main reason for the neglect of issues of economic efficiency. We have adopted an approach that applies contemporary human capital theory. Basic to this approach is the notion that the costs of and returns to training can be measured by comparing an individual's pay and allowances with his net productivity. In the typical case, the first term of service can be thought of as having three distinct phases: first, a period of basic military training and initial technical training; second, a period of on-the-job training (OJT),[2] when the value of the individual's productivity is less than the pay and allowances he receives; and third, a period during which the military earns returns on its investments in training because the person's productivity is greater than his pay and allowances. These three periods are illustrated in Fig. 1, where time t_1 represents the end of formal training, time t_2 the end of the period of investment in OJT, and t_3 the end of the first term of service. During formal training the individual's direct contribution to military capability is, by definition, zero. (Since he is not assigned to an operating unit, he could not possibly be contributing to current military effectiveness.) His *net* contribution, how-

[2] More precisely, a period of military investment in OJT, since OJT, in the sense of improvement in job-relevant skills, continues as long as one's productivity is increasing.

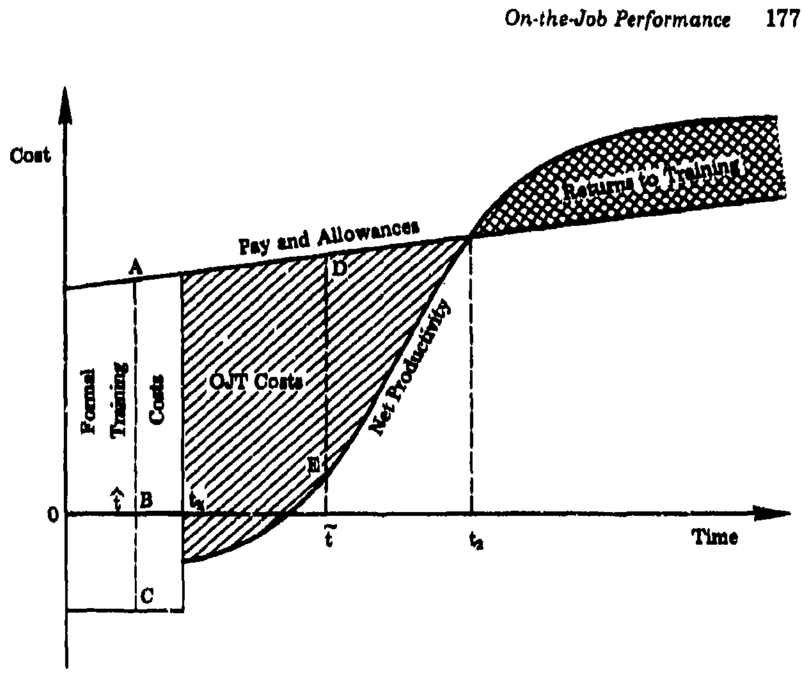

Fig. 1—Estimating methodology

ever, is negative, because training requires resources (instructional staff, classroom space, etc.) that could otherwise be contributing to current military capability. Therefore, the full cost of a person's formal training, say at time t, includes both the pay and allowances he receives (given by the distance AB) and the opportunity cost of the other resources devoted to his training (BC). After he completes formal training, his *net* contribution to military capability can be measured as the difference between his direct contribution and the opportunity cost of resources (such as supervisors' time) devoted to his OJT. The cost of OJT at a point such as t can be measured by the difference between his pay and allowances and his net productivity at that time (in this case, the distance DE).[3] The total cost of OJT is represented by the shaded area in Fig. 1.[4] Finally, there are returns to training

[3] In Fig. 1, the trainee's net productivity is shown as being negative immediately after completing formal training. This would occur if the forgone productivity of the trainee's supervisors exceeded his direct productivity. Although this is not necessarily the case, it does appear to be common.

[4] The shaded area in Fig. 1 represents the undiscounted sum of OJT costs. Since these costs are incurred at different points, they should be measured as a discounted sum. Similarly, formal training costs and returns to training should be measured as present

whenever the individual's net productivity exceeds his pay and allowances. These can be measured in the same fashion as the costs of OJT and are represented by the cross-hatched area in Fig. 1.

The major limitation to putting this sort of model into operation is the difficulty of estimating the time path of productivity. We have developed a method of estimating productivity using survey data and have recently collected data on members of about 50 specialties in the three major service branches. The remainder of this paper describes the data and the results of some early analysis. In the next section, the sorts of productivity measures we have used are described, as are the reasons for choosing them rather than alternative measures. We then present estimated productivity curves for six specialties and compare them to indicate the types of curves and relationships among them that are present in our data. Finally, we summarize our findings and indicate further directions for this research.

PRODUCTIVITY MEASUREMENT

The two most difficult problems associated with adequately addressing the issue of economic efficiency in military specialty training are (1) establishing an appropriate analytic framework for comparing the benefits and costs of additional amounts of training and, since the benefits of additional training take the form of increased productivity, (2) estimating actual productivity. We feel the human-capital model just outlined provides an appropriate framework for analyzing the effects of different amounts of formal training. This section deals with the problem of productivity estimation. The objective is to assess the advantages and disadvantages of several alternative approaches to the problem, focusing on both their conceptual appropriateness and the cost of gathering the type of productivity data needed to address the issue of economic efficiency in specialty training. The first step in this process is an elaboration of the properties that are important in such measures.

Properties of Productivity Measures

Three properties are crucial in productivity measures that are to be used to evaluate alternative specialty training policies, regardless of the analytical framework. The measures should (1) permit estima-

values, although as a practical matter formal training periods are typically so short that discounted and undiscounted values are identical.

tion of productivity over time, not just at a single point, (2) measure net rather than gross productivity, and (3) be linked with characteristics of the individual to whom they apply. Measurement of a time path of productivity is important because different types of formal training may affect productivity differently during the course of a military career. For example, in a comparison of two equally costly training courses where one emphasized the skills needed by a mature technician and the other emphasized the skills needed in the early months of a first-duty assignment, a measure that captured only productivity in the early months after completion of training would favor the latter course, whereas a measure that focused on productivity later in the career would favor the former. Adequate evaluation requires comparisons of productivity at a number of points so that comparisons can be made between courses with differential effects on productivity over time.

A second important characteristic is that net rather than gross productivity be measured. An individual's gross productivity is the amount he personally produces; his net productivity is the difference between the unit's production in his presence and its production in his absence. The two need not be at all the same, and the relationship between them can be expected to change systematically with experience. Consider, for example, a new specialty-school graduate joining a large radio repair shop. Although he will probably be able to complete some simple types of repairs, he will almost certainly need fairly close supervision. His gross productivity in these circumstances is positive, but if the reduction in his supervisors' production exceeds the trainee's direct production, his net productivity is negative. As he acquires more experience, his gross productivity will normally increase and the amount of supervision he requires will decrease, so that net productivity will rise more rapidly than gross productivity. At some point, supervision will become minimal, and gross and net productivity will, for all intents and purposes, be identical.[5] To the extent that the two measures differ, net productivity is clearly more appropriate for evaluating training, since it measures the difference in military effectiveness attributable to an individual. The use of gross productivity tends to bias analyses of substitutions between formal training and OJT in favor of OJT by overstating the trainee's productivity during his early experience, when supervisory inputs are greatest.

Finally, it is important to be able to relate productivity measures to characteristics of the trainees. Without measures of ability, background, attitudes, etc., it is impossible to compare training alterna-

[5] Of course, for those with substantial supervisory responsibilities, the relationship is reversed and net productivity exceeds gross productivity. This is not likely to be relevant during the period of interest here.

tives where there are significant differences in attributes or to estimate the effects of changes in the level of trainee quality.

Alternative Measurement Procedures

Measures having the properties just discussed can be gathered in a number of ways. Here we describe the strengths and weaknesses of two of the major alternatives which provide a basis for evaluating the measurement procedure we have used.

Substitution Measurement. The general character of the productivity measures that would be collected when unlimited resources are available is fairly straightforward. It would involve estimating an individual's net productivity by measuring a unit's output in his presence and in his absence. For example, the output of a particular radio repair shop could be measured with its full complement of personnel and then with various combinations of $n - 1$ personnel. The difference between the output of repairs with and without a given person is a measure of his net productivity. A time path of net productivity could be estimated either cross-sectionally or longitudinally.

One substantial difficulty in implementing this approach is the measurement of unit output. The problem arises primarily because there are many different types of output in a given specialty. To use the radio shop example, within a given shop several types of radios will be maintained and many types of failures will occur. If there are substantial variations in the difficulty of repairing different types of failures and in the mix of failures over time, the number of "repaired radios" that can be turned out in a given number of man-hours will vary a great deal. To take account of this, weights must be developed for different types of repair and output measured as a weighted sum of repairs. When the context is broadened to include multiple shops, the development of appropriate weights is even more important, since differences in equipment mixes among shops can introduce substantial differences in measured productivity if inappropriate weights are selected.

At first glance it might seem that once an unambiguous definition of output were developed, a small number of observations would be sufficient to evaluate two alternative training strategies, because the productivity measurements can presumably be made quite precisely. This is not true, however, because of the large number of factors besides military training that influence a person's contribution to unit performance. These include (1) his motivation, ability, previous education, etc.; (2) the number, experience level, motivation, ability, and previous education of other personnel in the unit; (3) the experience the group has had working together; (4) the stock of capital equipment; and (5) the demand for service that the shop faces. A large number of observations is necessary to control for these factors.

It should be apparent from the preceding discussion that the "ideal" sort of productivity measures would be quite costly to assemble and would, in spite of the cost, be less than perfect. Therefore, it is worthwhile to consider other alternatives, if suitable, less costly alternatives can be found. Only a limited amount of previous research has been done in this area, and because so little information currently exists on the topic, it is probably better to obtain a first approximation of productivity and economic efficiency of training for a number of specialties than to devote the same amount of resources to a detailed analysis of one or two specialties.

Job Tests. One approach that retains the characteristic of direct measurement but involves measures that are simpler to develop and administer is the use of job performance tests. This approach involves testing individuals on a specific set of skills used in their specialty. By testing people with different amounts of on-the-job experience, or testing one person several times, the relationship between productivity and experience can be established; and by linking these measures to measures of formal technical training, background, ability, etc., the effects of different initial training (controlling for personal characteristics) can be estimated.

There are several major limitations to this approach, however. Most important, it involves measurement of gross rather than net productivity. The OJT process in the military generally involves substantial inputs of supervisory resources, and therefore differences between net and gross productivity are likely to be large, especially early in the training process. Use of gross productivity will result in downward-biased estimates of OJT costs and therefore (because the returns to formal training are understated) will lead to policies that entail less than efficient amounts of formal training. A more subtle bias deals with differentials in supervision across individuals. The level of supervisory inputs to the OJT process would be expected to vary with the trainee's amount of formal training and his personal attributes. For example, if better trained, more able personnel require less supervision, gross productivity measures understate the differential in performance between them and those with less ability and training. This implies that gross productivity measures will fail to capture part of the returns to additional formal training and also that the relationships between personal characteristics and productivity estimated from gross productivity data will be biased. Finally, there are real questions of how well such tests measure actual gross productivity. Even if the set of job tasks accurately reflects the duties in a particular specialty, they need not be a good reflection of a particular individual's actual duties. Further, job tests measure a person's *ability* to perform those tasks, not his actual performance of them. The difference in the observed performance of two similar persons with, for example, different levels of motivation is likely to be much smaller during a short test than it would be over the course of several days or weeks on the job.

The Rand Method. The approach we have chosen uses supervisors' ratings of net productivity rather than direct measurement. This has the disadvantage of being a subjective measure, but it also has many advantages, especially since there has been so little previous analysis of the relationship between formal specialty training and productivity. This section describes the productivity measures that have been gathered and discusses the strong and weak points of the approach.

We have used a self-administered mail questionnaire to obtain supervisors' ratings of specific trainees' net productivity[a] at several points. Specifically, supervisors were asked to rate each trainee's productivity (1) during his first month with the unit, (2) at the time the rating was completed, (3) one year from the *time of the rating*, and (4) after completion of four years of service. In each instance, the supervisor was asked to rate the individual's net productivity relative to that of the typical specialist with four years of experience. Together these points trace out an estimated time path of relative net productivity that can be related to the attributes of the person being rated.

This method of estimating productivity is attractive for several reasons. First, it measures net rather than gross productivity. Second, it makes it possible to control for personal characteristics in comparing training alternatives. Third, the cost of data collection is relatively low, so that with a given budget many more specialties can be analyzed than would be possible using, for example, substitution measures. Although substitution measures would presumably lead to more precise estimates, at the present stage of research in this area it appears more valuable to explore the general magnitude and pattern of training effects across a number of specialties than to analyze a small number of specialties in great detail. Finally, because of the general nature of the measures that are obtained, comparisons across specialties are feasible both within a given service and between services. This feature is also important in obtaining a broad overview of the effects of training on productivity.

Two important limitations to our approach should be considered. First, the concept of net productivity is fairly sophisticated, and it is not one that enlisted supervisors are likely to have been familiar with

[a] Net productivity is defined as the difference between a trainee's gross productivity and the forgone productivity of supervisors who work with him.

before receiving the questionnaire. This raises the possibility that some survey responses will be invalid because supervisors did not understand what they were being asked to do. Recognizing this possibility, a great deal of time and effort in the survey design was spent developing and field-testing a clear explanation of the concept of net productivity. Of course, no such explanation could be clear to all recipients of the questionnaire, so a simple test of comprehension was included in the survey instrument. In addition, supervisors were asked to rate the "typical" technical school graduate and the directed duty assignment trainee,[7] which provides some insight into the rater's comprehension of the concept. Clearly, some responses will be unusable because the rater did not understand the concept of net productivity, but a preliminary analysis of the data does not indicate that this is a serious problem.

Another potential limitation is the possibility of important differences among raters in their rating systems: Some tend to rate easy and others hard, some tend to see people as very similar and some as very dissimilar. This has the potential for producing substantial distortion in the data, and a pilot study of our approach[8] suggested that it was indeed a serious consideration. An econometric model for dealing with this source of distortion by estimating parameters of the supervisor's rating system was developed in conjunction with that research and has been expanded and tested through Monte Carlo simulation.[9] It provides a means for controlling for supervisor rating effects. The ratings of the typical trainee provide another method, since for example, one would expect the supervisor who is a harder than average rater to give both the "typical trainee" and individual trainees low ratings. A preliminary analysis of our data suggests that a good deal of the possible distortion in the supervisor ratings is in fact eliminated by controlling for the supervisor's rating of the typical trainee.

PRODUCTIVITY RELATIONSHIPS

A very large, and, in many respects, unique data base has recently been assembled at Rand to provide a vehicle for analyzing the effects of different amounts of first-term specialty training. That data base includes members of over 50 specialties in the three major service

[7] A directed duty assignment trainee is one who goes directly from basic military training to an operating unit without attending a formal specialty training school.

[8] R. M. Gay, *Estimating the Cost of On-the-Job Training in Military Occupations: A Methodology and Pilot Study*, The Rand Corporation, R-1351-ARPA, April 1974.

[9] R.V.L. Cooper and G. R. Nelson, *Analytic Methods for Adjusting Subjective Rating Schemes*, The Rand Corporation, R-1685-ARPA, June 1976.

branches. When preliminary data processing is completed, an observation will include (1) the supervisor's rating of a trainee, (2) background information from service personnel records on both the trainee and the supervisor, and (3) additional background information on the trainee obtained from a survey he completed. The survey data were collected through sequential mail surveys of about 30,000 first-term enlisted personnel and an approximately equal number of enlisted supervisors. This section presents the findings of some very preliminary analysis of these data. Because we are at a very early stage in our work, we have adopted a rather elementary form of analysis—comparisons of estimated productivity functions over time in several specialties. In presenting these results, we intend to suggest a broad consistency between the observed patterns of productivity and those that would be expected a priori.

We first describe the data used in this analysis. The basic results are presented as a graphical comparison of estimated productivity curves for specific military occupational specialties. Finally, we illustrate both the potential and the pitfalls of using these sorts of data to analyze effects of training on productivity through an analysis of productivity curves estimated for the "typical" technical school graduate and for the directed duty assignment trainee.

Data Characteristics

Our productivity data consist of responses to questionnaires administered by mail to supervisors in a selected set of military occupational specialties. Supervisors were asked to provide three types of estimates of net productivity over time. First, and most important, are estimates of *specific individuals'* net contribution to unit productivity at four points during their first term of service: (1) during the first month on the job, (2) at the time the rating was completed (which will, of course, imply different amounts of on-the-job experience for different individuals), (3) one year from the time of the rating, and (4) after four years of service. Second, there are estimates of the typical technical school graduate's net contribution to unit production during his first month on the job, after one year on the job, after two years on the job, and after four years of service. Third are estimates of the typical directed duty assignment trainee's net contribution to unit production after one month, one year, and two years on the job, and after four years of service.

For purposes of the present analysis, we have selected a subsample of six of the 50 military occupational specialties for which data have been collected. The subsample was selected to include both a range of types of job tasks and a set of comparable specialties in different services. We have selected the light weapons infantry specialist (11B) and the hospital corpsman (91B) in the Army; the radio repair specialist (ETN) and the hospital corpsman (HM) in the Navy; and the radio repair specialist (304X4) and the hospital corpsman (902X0) in the Air Force. Observations for specific individuals were included only when a complete set of four productivity estimates was available and the trainee (1) was serving at his first duty station, (2) had attended technical school training, and (3) was serving in the specialty in which he was trained. Further, to eliminate responses where the supervisor's comprehension of the concepts was poor, we deleted those cases in which the supervisor rated the typical technical school graduate's productivity at 100 percent or more during his first month on the job or zero or less after four years of service.[10]

Average Productivity Relationships

Length-of-Experience Comparisons. Representative productivity curves for members of a given specialty can be estimated using ratings of the productivity of specific individuals as illustrated for the two Navy ratings (radio repairman and hospital corpsman) in Fig. 2. Average productivity during the first month on the job and after four years of service (points 1 and 8 in Fig. 2) can be estimated by taking the average value of the responses for all individuals in the sample.[11] Intermediate points are estimated by taking the average estimate of productivity at the present time and one year from now for groups of individuals in different experience categories. Specifically, we have grouped individuals into three experience categories: 5 to 9, 10 to 14, and 15 to 19 months of job experience. Points 2 to 4 in Fig. 2 represent the mean values of the estimates of productivity at the time of the rating for those in each of the categories (plotted at the midpoints of the intervals). Points 5 to 7 represent the average values of estimated productivity a year from the time of the rating for people in the same experience categories.[12]

On the average, these estimates of relative productivity for both the radio repairmen and hospital corpsmen conform to our expectations. The curves have positive slopes, reflecting an increase in productivity as a function of experience. Further, estimated relative produc-

[10] Using these criteria, the number of cases in each specialty were: 11B, 96; 91B, 197; ET, 252; HM, 85; 304X4, 689; and 902X0, 363.

[11] Since the horizontal axis of Fig. 2 measures on-the-job experience and point 8 corresponds to productivity after four years of service, the position of point 8 in a given specialty depends upon the length of formal technical training in that specialty.

[12] Cells with fewer than 10 observations were not included in the plots. For this reason, points 2 and 5 are missing for Navy hospital corpsmen.

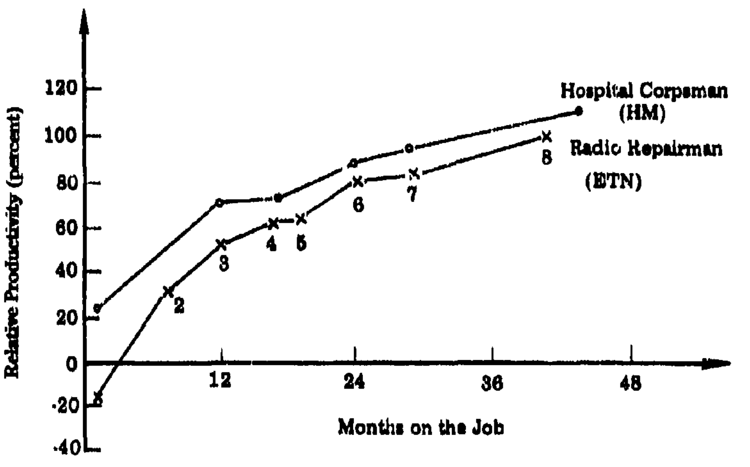

Fig. 2—Navy comparison

tivity after four years of experience approaches 100 percent in both specialties. Since productivity is being measured relative to the average specialist with four years of experience, average productivity at this point would be 100 percent in the absence of bias. Although the individual curves conform to expectations, there are nontrivial differences between them. The averaged ratings of the radio repairmen are consistently below those for the hospital corpsmen. This relationship was expected, since radio repair is more technically demanding and we would expect more experience to be required to attain proficiency. In addition, the differences between the two curves diminish over time, since each productivity estimate is made relative to that of a person with four years of service in that specialty. Figure 3 shows similar comparisons for the Air Force hospital corpsmen and radio repairmen. These productivity patterns are similar to those seen in the Navy. Initial net productivity is negative for radio repairmen and positive for hospital corpsmen, and the differences in relative productivity diminish with experience. The curves for the two Army specialties (hospital corpsman and light weapons infantryman) shown in Fig. 4 are less clear-cut. Here it is not so obvious which is the more technically demanding specialty, and, moreover, the differential in productivity does not decline over time as expected.

Another way of exploring the consistency of our estimates is by comparing estimates for similar specialties in different services. The

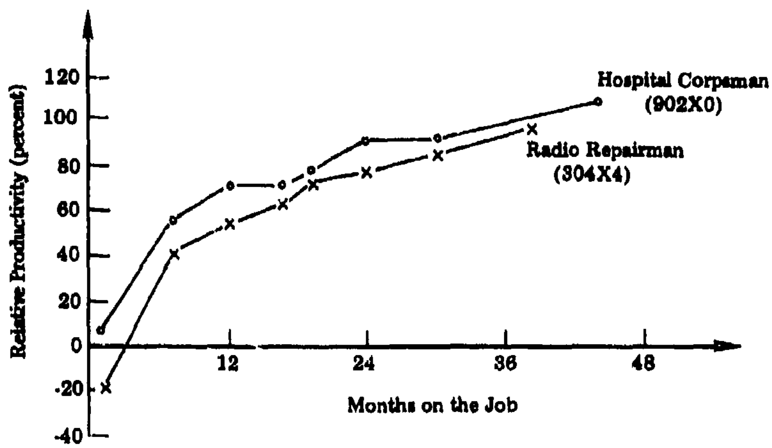

Fig. 3—Air Force comparison

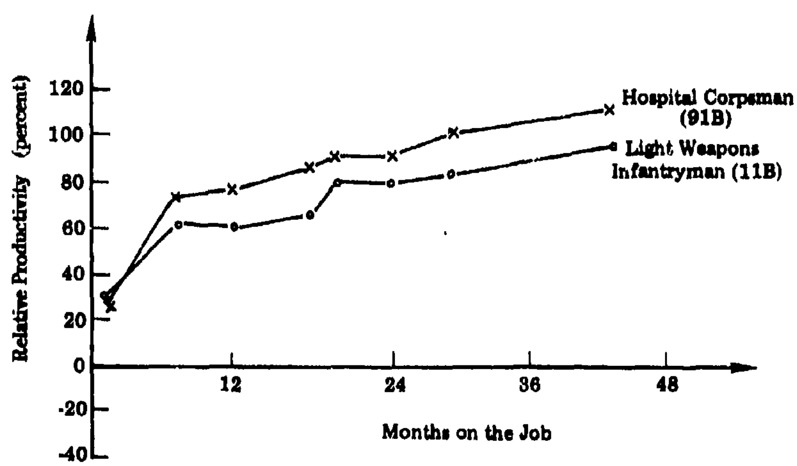

Fig. 4—Army comparison

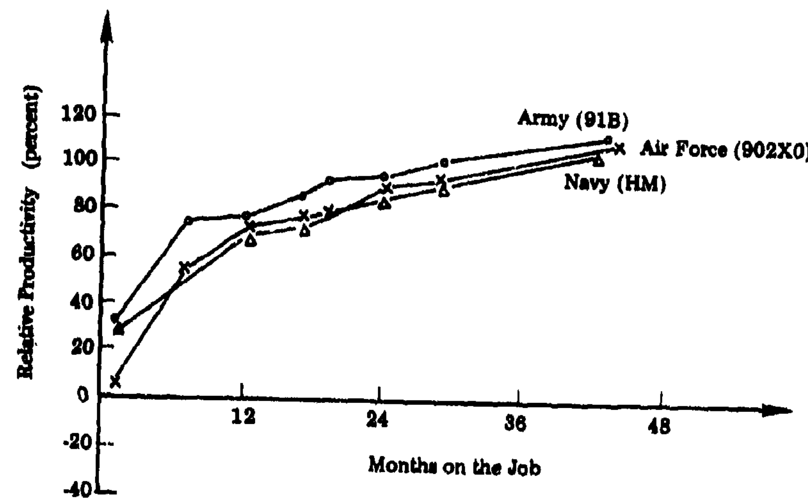

Fig. 6—Hospital corpsman comparison

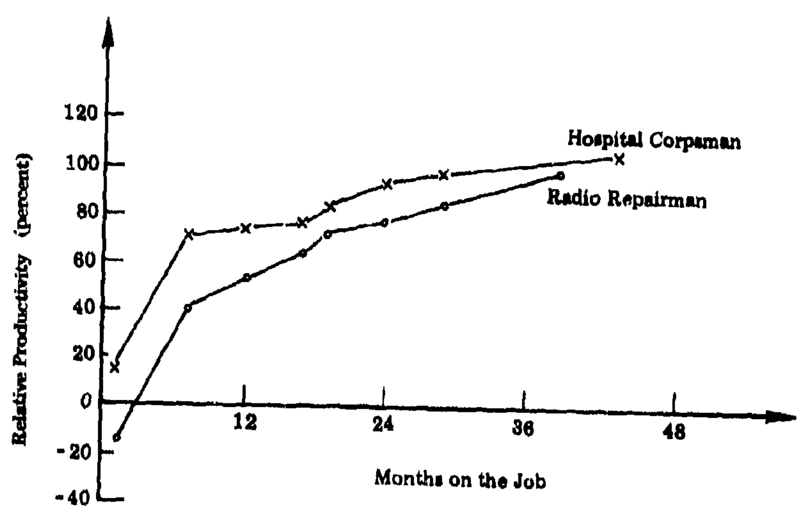

Fig. 7—Servicewide comparisons

As a group, these results are quite encouraging. The observed productivity relationships are consistent with expectations in terms of both the patterns observed over time in a given specialty and the relationships among specialties. The results suggest that the productivity estimates we have assembled will be useful in appraising alternative training policies.

Graduate-Nongraduate Comparisons. Both the potential and the pitfalls of using these types of data to analyze the effects of training on productivity can be illustrated by comparisons of productivity curves estimated as averages of supervisors' performance ratings of the "typical" technical school graduate and the "typical" directed duty assignment trainee. Unlike the curves estimated from ratings of specific individuals, these curves chart the progress of hypothetical typical trainees through the first term of service.

The four curves in Fig. 8 present such comparisons for the Navy and Air Force radio repairmen (ETNs and 304X4s). The curves exhibit properties consistent with expectations of productivity estimates in general and are similar to the average curves estimated for specific individuals. The Navy radio repairman curves (represented by the solid lines) show substantial and persistent differences between graduates' and nongraduates' performance throughout the first four years

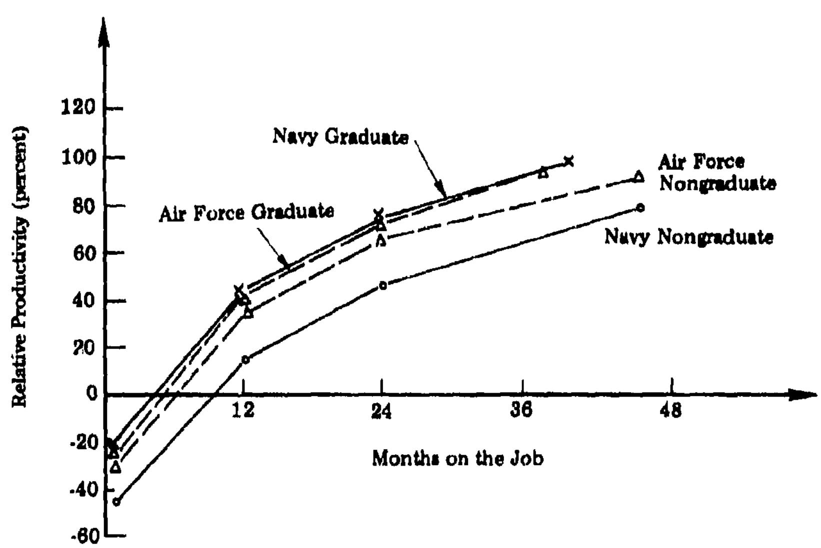

Fig. 8—Combined radio repairman graduate-nongraduate comparison

of service and suggest that returns to training may be substantial. Productivity curves for the Air Force radio repair specialty (represented by the dotted lines) exhibit a similar relationship between estimates of graduates' and nongraduates' productivity, but the differences between the two curves appear to be much smaller than those between the two Navy curves.

Either of these two set of curves, taken alone, might tend to imply that there is a difference in training effectiveness between the Navy and the Air Force, with the higher returns to training occurring in the Navy. Consideration of the two sets of curves together, however, raises questions about this interpretation. The two productivity curves for the technical school graduates are practically identical; the differences between the services arise because Navy nongraduates have poorer performance than Air Force nongraduates. This suggests that the apparent difference in returns to training between the two services may, in fact, be a reflection of differences in relative quality of graduates and nongraduates rather than differences in training effectiveness. That is, Navy and Air Force technical school graduates may be roughly comparable in aptitude, education, etc., whereas Navy directed duty assignment trainees may be less able than their Air Force counterparts. Of course, with this sort of analysis, it is not possible to sort out the effects of differences in personal characteristics from those of differences in training effectiveness. The results do suggest, however, that we are likely to observe systematic differences in the performance of graduates and nongraduates, and that in analyzing them it will be important to control for trainees' personal characteristics.

SUMMARY

Analysis aimed at determining the most efficient *amount* of technical school training must be conducted in a framework that permits estimation of the effects of that training on post-training job performance. The approach we have adopted applies human-capital theory, in which the costs of OJT and returns to training are measured by comparing individuals' pay and net productivity. The key element in implementing this approach is the estimation of on-the-job productivity. We have used supervisors' estimates of individuals' net productivity at various points in their first term of service to construct estimates of the time path of productivity. A number of estimated productivity paths were presented to show the general character of the data we have collected. All the productivity curves for the six specialties studied here showed a positive slope that tended to decrease over time (the rate of improvement declined with experience). Moreover, comparisons among specialties tended to conform to expectations, both when those comparisons were made between specialties in the same service and when they were made between comparable specialties across services.

Encouraging as these results are, they are no direct help in appraising the relative efficiency of various amounts of technical school training. Two steps are necessary before this issue can be addressed. First, the productivity estimates must be integrated into a broader framework such that training costs and returns can be estimated. Second, estimated net training costs (formal training costs plus OJT costs less returns to training) must be analyzed for individuals with differing amounts of formal training, and as the analysis of the "typical trainee" data suggests, this analysis must be done in a multivariate framework that controls for other factors that influence estimated productivity.

ALTERNATIVES TO PERFORMANCE TESTING: TESTS OF TASK KNOWLEDGE AND RATINGS USING BEHAVIORAL ELEMENTS AND TASKS AS ENTITIES

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With the elimination of the draft, reliable assessment of job performance is more crucial than ever. The services need assurance that job incumbents can prform effectively and that fair and valid tests are used for qualification and advancement. Service attractiveness is likely to increase as a side benefit of fairer and more objective performance evaluation.

The development of full performance tests, i.e., tests that approximate job performance as closely as possible is described, along with two alternative approaches to full performance testing.

The discussion of performance testing focuses on issues in sampling and simulation as they relate to test validity. The discussion of alternatives to performance testing describes two approaches being developed: (1) a procedure for rating performance using an extensive set of detailed worker-oriented items, and (2) a type of simulation that requires the examinee to discriminate between correct and incorrect task performance.

In this paper we will discuss a combination of methods for assessing job proficiency that we have been studying at HumRRO.[1] A convenient way to classify alternative approaches to assessing task or job proficiency is to consider the relevance of what is being measured to actual performance. In this way we can identify at least five general strategies. In decreasing order of correlation to actual task or job performance they are:

[1] Part of this work is supported by ONR and part by the Army.

1. Measurement of actual job performance, where the only change is recognition that a test is being conducted.
2. Measurement of performance on job sample tests, sometimes in an approximation of the job environment.
3. Measurement of performance using simulations involving varying degrees of difference between the actual and simulated stimuli and/or responses.
4. Measurement, not of performance but rather of information on how a task or job is to be performed—knowledge that should correlate with actual performance.
5. Neither the direct measurement of a subject's performance or the direct measurement of his knowledge but rather the appraisal by a second party, usually a supervisor or sometimes a peer, of how the subject carries out his job.

The first strategy, the measurement of actual performance on the job, is rarely used, in the sense of measuring actual job activities or processes. It is seldom feasible, there are problems of standardization, and the cost is extremely high. The measurement of job output or the product of job performance, although limited to tasks that generate a permanent and objective record and also facing problems of standardization, is probably more common.

The second method of assessing performance, job sample testing, is about as close to the ideal as we can get from a measurement point of view, but it is also extremely costly.

The third method, using simulated job measures, is probably more feasible but can be risky, given our incomplete understanding about the properties of cues and responses that must be modeled to obtain valid measurement.

Fourth, the measurement of job knowledge, although the most feasible and least costly approach to direct measurement, suffers in that it often does not provide an adequate correlation with actual performance. However, knowledge tests can correlate fairly well with performance if they are constructed with care and cover content that is clearly relevant to performance. In a study that we conducted some years ago in which we administered lengthy job sample tests and knowledge tests to over 1,600 subjects holding four different Army jobs, we obtained correlations between job sample and knowledge test scores ranging from .58 to .72.

The last strategy, the use of ratings, clearly is the easiest and most frequently used method, but it probably correlates least well with any of the direct measures of performance—a shortcoming that can be ascribed to difficulties of maintaining objectivity with indirect measurement. Also, ratings are often fairly nonspecific about the tasks or behaviors the job comprises.

Our present work has focused on the last two methods, knowledge testing and ratings, the most feasible but least related to the job.

Let us first discuss knowledge testing, the work we are doing for the Army. It is based upon two notions: First, knowledge testing should be restricted to tasks that do not involve skilled behavior or that have low skill requirements. Second, knowledge testing should focus on the performance of specific tasks and should contain items that possess all or most of the knowledge that is relevant to the performance of these tasks. It should not consist of items of general job knowledge or individual elements of knowledge that have been isolated from the totality of information needed to perform a task.

In other words, knowledge tests should not be used to assess skilled behavior. A simple test of whether a task is skilled or nonskilled is to describe it in detail to an untrained person. If he can perform it, the task is nonskilled and a knowledge test may be used. Examples of such tasks are changing a tire, dialing a long-distance call, or keeping score in golf.

Skilled tasks, on the other hand, require practice or rehearsal during learning. Examples are aiming a rifle at a moving target, moving materials using a crane, and driving a golf ball accurately. Practice is required in learning such skills, for a variety of reasons: to discover precise movements or behaviors that are difficult to describe; to make adjustments in the behaviors themselves; to gain speed, coordination, or timing; and occasionally to "overlearn" so there will be stability of performance under conditions of stress. While practice may accomplish different things during learning, the role that it plays is not important for purposes of test construction. The mere fact that practice is required to learn a task is sufficient to classify that task as skilled and to indicate that something other than a knowledge test is needed. Even when it is possible to describe a skilled task verbally, such a description cannot be expected to impart that skill to another person. Likewise, the ability of a job incumbent to describe skilled behavior cannot be used to infer that he can indeed perform the task.

We should add parenthetically that there are some tasks that require practice during learning but that are not properly classified as skilled. These are tasks that are perfectly communicable by verbal means but which are so lengthy as to require several trials to be committed to memory. While there may be some practical problems in testing these tasks on the basis of information about them, they are measurable—in theory at least—with knowledge tests.

To our knowledge, development of tests that focus on specific tasks and contain all the information required to perform them has never been undertaken in any systematic way. However, over the last year or so the Army has been developing a new system of testing to determine a soldier's job proficiency and whether he is qualified for promotion. In this effort, the Army has focused on the tasks that it deems critical in each job, emphasizing task performance. If it were possible, the Army would use performance tests entirely.

We have just completed a manual for the Army on procedures for constructing both performance tests and knowledge tests of tasks. Both types of tests begin with the same materials: detailed listings of the behavioral elements of a task. In the case of knowledge tests, these elements are then analyzed to identify the components of knowledge that bear on the performance of each behavior. It is interesting to note that if a task has been properly analyzed and if a performance test is to be constructed, no further breakdown of the behavioral elements is necessary. The elements translate directly into observable measures of performance. However, in the case of a knowledge test, many elements must be broken down into finer subelements. For example, one of the behavioral elements in adjusting the hydraulic brake on an M-60 tank is "loosens both jam nuts on the brake pedal-master cylinder tie rod." The separate bits of knowledge included in the performance of this step are at least:

1. Knowing the location of the tie rod.
2. Knowing the location or appearance of the jam nuts on the tie rod.
3. Knowing that the jam nuts need to be loosened.

As a matter of fact, while there are ten steps that should be observed in measuring performance of this task, there are at least 36 separate items of knowledge that can be measured. To find out if a job incumbent knows what to do and when to do it, we need to assess all or almost all of these items.

To keep the number of knowledge items within a reasonable limit, we have developed about a half-dozen rules for selecting items that seem likely to give adequate coverage of a total task.

Now, assuming that we can test proficiency for nonskilled tasks through these specially devised knowledge tests, what can be done short of performance testing to assess proficiency in skilled tasks? Our work for the Navy may provide some answers to this.

In our Navy research, we are trying to devise methods for rating performance that may be more discriminating than traditional ratings. To do this we are exploring ways to be more elemental or specific in the rating process and are using two models to arrive at more detailed descriptions.

In describing different approaches that have been taken to job analysis, Ernest McCormick has distinguished between "worker-oriented" variables and "job-oriented" variables. Worker-oriented variables focus upon human behaviors that tend to be generalized across tasks. Job-oriented variables focus upon job content characterizing technological objects of performance or achievements of the worker.

Examples of worker-oriented variables or descriptors would be "estimates speed of moving objects," "obtains information from written materials," "engages in information exchange," and "activates fixed setting conrols." Examples of job-oriented variables are "uses wiring diagrams," "repairs coaxial cables," "anneals copper tubing," and "drafts business letters."

To develop rating procedures based upon a worker-oriented model, we used McCormick's Position Analysis Questionnaire to obtain job analysis data for 10 Navy jobs that we believe are quite dissimilar.

The Position Analysis Questionnaire is a structured job analysis instrument that consists of 189 job elements of a worker-oriented nature. From the job analyses obtained with this questionnaire, we extracted only those behavioral elements that were described as average or better in importance or frequency.

We have also taken all of McCormick's items that describe the elements of job structure and translated them into items suitable for rating performance. We have constructed performance rating questionnaires containing only the translated items for those elements that were seen as most relevant in the original job analyses.

Our next step will be to ask supervisors (and perhaps peers) to rate the performance of individuals in these jobs with respect to these specifically selected job elements. Depending upon the job, a individual will be rated on 30 to 60 worker-oriented behavioral elements.

Now let us consider our other approach to performance ratings. To develop rating procedures based upon a job-oriented model, we are using job task inventories that have been collected as part of the Navy Occupational Training Analysis Program (NOTAP). From this program we have obtained lists of tasks performed by at least 50 percent of the incumbents in the jobs we are studying. We are now constructing job-oriented rating instruments using these specific tasks.

We will collect performance rating data with these instruments from the same supervisors who used our worker-oriented procedures.

We anticipate that performance ratings obtained with the worker-oriented instruments may tend to distribute more normally than ratings obtained with the job-oriented instruments. Ratings generally have a tendency to pile up at the positive end of the scale, and this is perhaps more likely to be the case where specific job tasks are being rated with the job-oriented instrument, since supervisors are usually responsible for ensuring the effectiveness of their personnel. A poor rating then reflects upon the supervisor as well as the worker. Hence we might expect more inflated appraisals of task performance using a job-oriented approach with specific task names as variables. However, it may be that a supervisor can be more objective in his ratings of elements that are taken from the entire job, i.e., in his rating of worker-oriented variables.

In this study we expect to compare the outcome from both of these kinds of instruments with the distributions obtained under the Navy's present performance rating system. We also plan to obtain some information on the concurrent validity of these instruments by comparing the performance ratings of experienced and inexperienced job incumbents.

Finally, as part of our work for the Army, we plan to conduct a study in which soldiers will take performance tests and knowledge tests and also will be rated with worker-oriented and job-oriented instruments. This last study will give us our most definitive information about the efficacy of using knowledge tests of tasks, and worker-oriented or job-oriented ratings as substitutes for performance tests.

A LONGITUDINAL ASSESSMENT OF ORGANIZATIONAL EFFECTIVENESS

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Efficient management of large organizations requires that systematic evaluative information be made available on a continuing basis to assess the productivity of organizational subunits and to ensure the viable operation of the system as a whole. It is equally important that adequate procedures exist for capitalizing on this information to the fullest possible extent in attempts to improve the effectiveness of the organization. A large-scale research effort has been directed at providing detachment evaluation data to the Air Force ROTC program. This research effort has also furnished methodologies to permit Hq AFROTC to continue to update their material.

Multiple criterion measures were used in the analysis, including traditional enrollment, production, and unit cost data, as well as several longer-range indices of productivity based on graduate performance after entry to active duty (i.e., training elimination rates, on-the-job performance, and retention). Criteria were developed by detachment for each year's input from 1964 to 1974 (based on 100,000 individual case records).

Multiple-regression techniques were used to investigate sources of potential influence on the criteria: institutional characteristics of the host college and program variations unique to the detachments. Applications of results in the assessment of both current detachments and potential host sites are discussed, and implications for policy change are summarized.

INTRODUCTION

Efficient management of large organizations requires that systematic information be made available on a continuing basis to assess the performance of organizational subunits. It is equally important that adequate procedures exist for capitalizing on this information to the fullest possible extent in attempts to improve the effectiveness of the organization as a whole. This paper summarizes a large-scale research effort to provide unit evaluation data and associated analytic capability for the Air Force Reserve Officers Training Corps (AFROTC) program.

The impetus for the study originated in DoD directives during the late 1960s that each service examine its ROTC program annually with a view toward augmenting cost-effective units, disestablishing marginal ones, and seeking new host institutions that might provide more suitable environments for an ROTC program. Until that time, there had been little systematic effort to develop quantitative procedures for evaluating existing detachments or for selecting new host sites. Nor was there even a broad consensus about which criteria should be used to evaluate unit effectiveness. It was important that a minimum number of graduates be produced at reasonable cost. There was a growing awareness, however, that there might be qualitative differences in detachment output that, in some cases, would not become evident until after graduates entered active duty. Certain types of graduates, for example, would not complete subsequent technical training programs. Other characteristics might influence in part how well cohorts perform on the job and ultimately whether or not they elect to become career officers. A principal goal of this effort was to extend the detachment evaluation system to include both near-term and long-term unit-effectiveness criteria that could be monitored over time.

Aside from requirements for improved criteria, research was also needed to identify and investigate the principal determinants of performance at the institutional level. AFROTC management has long been aware that productivity at larger institutions has typically been greater than at schools with smaller enrollments. The academic rating of a host institution, its geographic location, and its type of control (public or private) might also influence productivity to some unknown extent. Until recently, however, there has been no firm basis established for quantifying these relationships to assess their contributions to predicting detachment performance.

Thus far, the preliminary results of work in this area have served mainly to establish the basic feasibility of the approach used (Tupes et al., 1968; Tupes and Madden, 1968, 1970; Alley, 1974; Alley and Berberich, 1975(a), (b)). The data base used in these early studies was limited in a number of important respects. In the interests of establishing a single time-line between entry and exit from the personnel system, the tracking of input groups was limited to persons entering service before 1965. As a result, most of the production, cost, and training criteria were somewhat dated. Similarly, many of the institutional characteristics used for explanatory purposes were of limited value either because they were unavailable for certain schools or because they were difficult to update. It was necessary to update the system to include all information available on officer accessions from 1964 to the present and to explore new measures that might be both readily accessible and amenable to update.

This paper presents the final results of this research. The principal research questions addressed in the study can be summarized as follows:

1. *To what extent are there stable differences in detachment performance across criteria and across time?* The intent here was to assemble data and develop normative statistics for each of the available criteria from 1964 to 1974 and to determine if there were sufficient stability in these measures for evaluation purposes. It was recognized that some of the criteria would remain invariant, while others would not. Those that appeared inconsistent over time (were sensitive to short-term influences or modifications in the operation of a detachment) might be useful in making comparisons between existing detachments but would be of little value in evaluating a proposed detachment site. Highly stable criteria, which presumably reflected more enduring characteristics of the detachment or the surrounding environment, could conceivably serve both evaluative and forecasting purposes.
2. *To what extent can differences in detachment performance be attributable to influences beyond management control?* The answer to this question also has several important implications for the evaluation of both current detachments and potential host sites. If, for example, detachment performance was functionally related to characteristics of the institution at which it operated, then a more equitable evaluation procedure could control for these factors. Evaluation of potential host sites would also be enhanced if supporting documentation could be developed that indicated the observed relationships were stable enough to generalize to new institutions at some future time.
3. *To what extent can differences in detachment performance be attributable to controllable features of the AFROTC program?* For example, the length of training (two or four years) might influence the number or quality of graduates. By estimating the unique influence of these factors, management decisionmakers would be in a better position to evaluate proposed modifications and their expected consequences on the performance criteria.

APPROACH

Detachment-Effectiveness Criteria

A multidimensional assessment system was developed for evaluating detachment performance. The effectiveness criteria included traditional enrollment, production, and unit cost measures, as well as several longer-range indices of productivity based on graduate performance after entry to active duty (training elimination rates, on-the-job performance, and retention). Criteria were developed by detachment for every year's input from 1964 to 1974 (N = 65,000 individual case records). The basis for defining the criteria is illustrated in Fig. 1, which diagrams the flow of graduates from a detachment through a simplified personnel system. The progress of various categories of personnel (pilots, navigators, and nonrated officers) can be followed longitudinally from initial entry into the AFROTC program through various active duty training programs and eventual field assignment to an arbitrary point beyond obligated service commitments. The effectiveness criteria represent aggregated measures by detachment and are expressed in the form of absolute numbers, percentages, averages, and unit costs, characterizing the individual cohorts at various stages in the system. Detachment criteria selected for the present analysis are shown in Table 1, grouped into four broad categories: (1) enrollments and production, based on the total number of students either enrolled or graduated during a given year; (2) cost effectiveness, derived from unit costs associated with graduation from AFROTC; (3) officer quality, based on the typical performance of detachment cohorts on various qualitative measures derived from officer selection tests, success in pilot training, and supervisory ratings of on-the-job effectiveness obtained during the first four years of active duty; and (4) retention, based on the proportion of detachment graduates remaining in service beyond initial active duty commitments.

Institutional and Program Characteristics

For purposes of this study, it was useful to distinguish between two sources of potential influence on the criteria: institutional characteristics and program characteristics. The institutional variables define the environmental context in which the detachment must operate. They index the relative quantity and quality of student resources from which the cadet population is typically drawn, the location and control of the institution, the number and proportion of degrees awarded in various academic areas, and a general summary of revenue sources. This information was obtained from three standard refer-

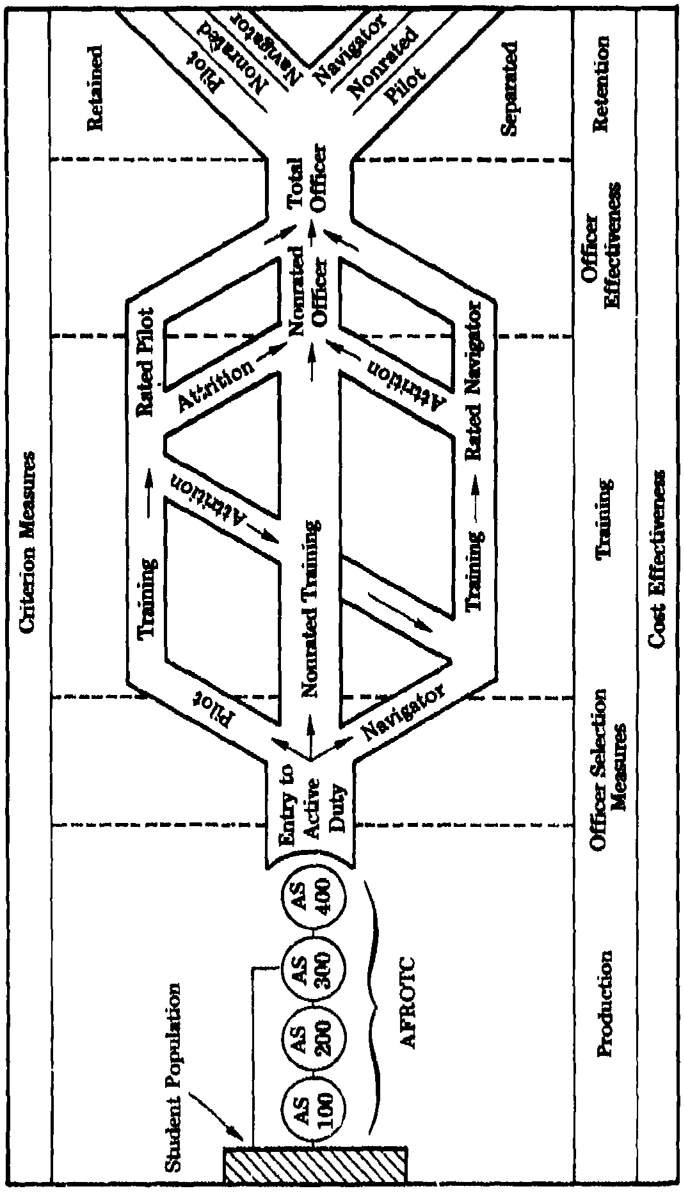

Fig. 1—A schematic representation of the AFROTC personnel production system

Table 1

DETACHMENT EFFECTIVENESS CRITERIA

Criterion Variable	Description
Enrollment/production	
AS300 enrollment (AS300)	Based on the average number of AFROTC students enrolled in Air Science 300 during 1970-1975.
Graduate production (Grads)	The average number of graduates produced during 1970-1974.
Cost effectiveness	
Unit cost per graduate (CPG)	The average cost of producing a single graduate during 1970-1974, obtained by dividing the total annual cost of detachment operation by the number of graduates; does not include costs associated with the College Scholarship Program or Flight Instruction Program.
Total detachment cost (TDC)	The average annual cost of detachment operation during 1970-1974; does not include costs associated with the College Scholarship Program or Flight Instruction Program.
Officer quality	
AFOQT-OQ composite score (AFOQT)	Based on the proportion of graduates entering service during 1968-1973 who scored above the 55th percentile on the Air Force Officer Qualifying Test-Officer Quality Composite. This composite reflects performance on the verbal, quantitative, and officer biographical portions of the test battery. A score at the 25th percentile is a minimum requirement for a commission in the Air Force.
Pilot training success (Pilot)	The proportion of detachment graduates successfully completing Undergraduate Pilot Training; based on those entering training during 1964-1972.
Officer effectiveness reports (OER)	Based on the mean adjusted OER ratings obtained by detachment graduates during their first four years of service. The OER is a supervisory rating provided for each subject at six-month intervals. This metric has been adjusted for research purposes to remove the effects of inflation and form changes over time (Tupes and Dieterly, 1968). Ratings for all entrants during 1968-1972 were included.
Retention	
Graduate retention (Ret.)	The proportion of detachment graduates remaining in service beyond initial active duty commitments. Based on entrants during 1963-1964.

ences available in most academic libraries: (1) *American Universities and Colleges*, 10th Edition, (1968); (2) *The College Blue Book*, 14th Edition (1972); and (3) *Earned Degrees Conferred, 1970-71* (1973). A full description of these variables is given in Table 2. The division of the institutional predictors into subsets was based more on practical than on theoretical considerations. Subset 1 represents an array of predictor variables that have been shown in preliminary studies to be highly related to the enrollment, production, and cost criteria and are at present on file for a large number of potential host sites. These measures include host college student enrollments, American College Test (ACT) scores for entering freshmen, geographic region, institutional type, control, and indicators of predominantly male and minority representation. Subset 2 contained supplemental information that can be accessed quite readily and that seemed to show some promise as explanatory variables for the quality of detachment output. Included among these variables were religious affiliation, average worth of undergraduate scholarships, tuition costs, Ph.D.s awarded per enrollment, and a general summary of revenue sources. Subset 3 represented the degree orientation of the host institution based on definitions suggested by Astin (1965).

Program characteristics, in contrast to the institutional variables, were controllable features of the detachment at least from the standpoint of AFROTC management. These variables defined the operating characteristics of the detachment itself, whether it was collocated with a detachment from the other services, whether arrangements had been made to enroll students from other collegiate institutions in the vicinity (cross-town agreements), and whether a two-year (only) program was offered as opposed to an optional two- or four-year program. To the extent the program influences can be shown to determine the effectiveness of a detachment, AFROTC management will be in a better position to select from among various planning options so that effectiveness, however defined in terms of the criteria, can be maximized within practical constraints.

Design of Analyses

Multiple regression techniques as outlined by Ward and Jennings (1973) were used to establish predictive relationships with the criteria and to test various hypotheses about these relationships. The units of observation were detachments operational during a given period. Documentation of results was obtained in the form of means, standard deviations, correlations, raw score regression weights, and F-statistics. The overall conceptual model for analyzing the institutional and pro-

Table 2

Definition of Predictor Variables

Variable	Source	Definition
Institutional Subset 1		
Total male enrollment	ACE	Literal coding format. Includes the total number of full-time male undergraduate enrollments.
Total enrollment	ACE	Literal coding format. Includes the total number of full-time male and female enrollments at the undergraduate and graduate levels.
Average ACT composite	ACE	Literal coding format. This number reflects the average ACT composite for entering freshmen. For schools at which the Scholastic Aptitude Test mathematics and verbal scores only are available, reference is made to conversion tables found in Astin (1971).
Students per faculty member	CBB	Literal coding format. Obtained by dividing the total enrollment by the total full-time faculty.
Geographic region	CBB	Categorically coded 1 if applicable; Ø otherwise. States included in each region are listed below:
New England		CT, ME, MA, NH, RI, and VT
Mid-East		NY, PA, NH, DE, MD, WV, and DC
Great Lakes		OH, IN, MI, IL, WI, and MN
Plains		ND, SD, NB, IA, MO, and KS
South East		VA, NC, SC, GA, FL, AL, TN, MS, AR, LA, and KY
South West		TX, OK, NM, and AZ
Rocky Mountains		MT, WY, CO, UT, and ID
Far West		NV, CA, OR, WA, HI, and AK
Institutional type	ACE	Categorically coded 1 if applicable; Ø otherwise.
University		
Liberal arts college		
Teachers college		
Technical institute		
Public Control	ACE	Categorically coded 1 if the institution is under public control; Ø if private.
Predominantly male	ACE	Categorically coded 1 if the percentage of males in the undergraduate student body is greater than 75 percent; Ø if predominantly coed. Note that this variable does not include provisions for predominantly female institutions since at no time have AFROTC detachments operated in this type of environment.

Table 2 (Continued)

Variable	Source	Definition
Institutional Subset 2		
Religious affiliation	ACE	Categorically coded 1 if applicable; Ø otherwise.
Nonreligious/nonprofit		
Roman Catholic		
Other religions		
Average scholarship value	ACE	Literal coding format. Average dollar value of scholarships awarded.
Tuition per student	ACE	Literal coding format. Based on the average dollar value of all tuition revenues divided by the total student enrollment.
Endowment—Percent of revenue	ACE	Literal coding format. Percentage of total revenues obtained through endowment funds.
Ph.D. awards per enrollment	ACE	Literal coding format. Proportion based on the number of Ph.D.s awarded to the total student enrollment.
Total revenue per enrollment	ACE	Literal coding format. Based on the total annual revenues divided by the total student enrollment.
Institutional Subset 3		
Degree orientation	OE	Literal coding format. Represents the total percentage of degrees offered in 24 specialties grouped into seven broad areas. Career fields included in each area are listed below. Note: Totals add to 100 percent.
Realistic		Agriculture, Architecture, Engineering, Geology
Scientific		Biology, Computer Sciences, Mathematics, Physical Science
Social		Education, Health, Psychology, Social Sciences
Conventional		Business, Home Economics
Enterprising		Area Studies, Banking & Finance, Law, Economics, History, Political Science
Artistic		Fine & Applied Arts, Foreign Languages, Letters
Aerospace		Aerospace Engineering
Program characteristics		
Collocated ROTC (A)		Categorically coded 1 if there are Army or Navy ROTC detachments collocated with the Air Force unit; Ø otherwise.
Cross-town agreements (B)		Categorically coded 1 if the detachment has arrangements to enroll students from other collegiate institutions in the vicinity; Ø otherwise.
Two- versus four-year program (C)		Categorically coded 1 if the detachment offers a four-year ROTC program; Ø if only two-year programs are available.

NOTE: ACE = *American Council on Education*; *CBB* = *College Blue Book*; *OE* = *Office of Education*; *ACT* = *American College Test*; and SAT = Scholastic Aptitude Test.

gram correlates of each criterion in turn can be characterized as follows:

$$(DC_p) = (IC) + (PC_p)$$

where DC_p = detachment criteria for year p,
IC = institutional characteristics, and
PC_p = program characteristics for year p.

The detachment records within a given year were analyzed separately for two randomly split half-samples and for the total sample. The half-sample analyses provided a means for cross-validation of results. In certain applications of these data (as in estimating the suitability of a potential host site), it will be necessary to make inferences about future performance at schools that were not included as part of the validation sample. Thus it was necessary to evaluate the stability of the prediction equations across both time and institutions. Detachments in continuous operation during 1964-1974 were divided into two random half-samples. Within each half-sample, the criterion data were split into two time segments, designated T1 and T2. Estimates of potential error arising from variations between samples over time were obtained by developing equations on half-sample 1 during T1 and cross-applying the weights derived to the second half-sample at T2. The cross-validation estimates generated in this exercise are considered conservative in the sense that greater stability would be required to establish statistical significance than would be the case if the full-sample equations using criteria combined across both time periods could be subjected to the same procedure. Results from the total sample of detachments permitted comparisons between various subsets of the predictors and the criteria and also provided working models for the system.

RESULTS AND DISCUSSION

Normative Characteristics of Detachment Criteria

Normative data for the effectiveness measures together with mean intercorrelations between years are shown in Table 3. The correlational data may be taken as indicators of criterion stability across time for the entire inventory of detachments. Consistency between years appeared to be highest for the enrollment, production, and total cost criteria. Correlations between years for these criteria ranged from .82 to .96. Somewhat less stable but still moderately consistent across time were the AFOQT and retention criteria. The only criterion

Table 3

DETACHMENT CRITERION MEANS, STANDARD DEVIATIONS, AND MEAN INTERCORRELATIONS BETWEEN YEARS

Criterion	N	M	SD	Mean R Between Years
AS300 enrollments	140	26	16	.82
Graduates	140	25	16	.85
Cost per graduate	140	10,673	4,446	.39
Total detachment cost	140	205,002	76,901	.96
AFOQT-OQ	140	65.72	13.72	.64
Pilot training completion	140	76.82	8.56	.22
Officer effectiveness	138	34.16	2.42	.35
Retention	137	48.44	11.74	.53

that appeared seriously deficient in terms of stability over time was pilot training success rate, where between-year correlations averaged .22. In the analysis of predictive relationships described below, the effects of these inconsistencies have been moderated to some extent by basing the assessment system on measures reflecting several years of input for each detachment.

Estimation of Detachment Performance

Means, standard deviations, and zero-order correlations between the institutional and program characteristics and the detachment criteria are shown in Table 4. The school enrollment measures, for example, are shown to be positively related to production criteria, total detachment costs, performance on the AFOQT, pilot training success, and mean Officer Effectiveness Ratings (OER). Enrollments were negatively related to unit cost per graduate and had no apparent relationship to retention. The effects of average ACT scores at the host institution were somewhat more varied across the criteria. While having only a slight negative influence on enrollments and production, average ACT was positively related to cohort performance on the officer quality measures (AFOQT, pilot training success, and OER) but negatively related to officer retention. The average number of students per faculty was minimally related to all criteria except for AFOQT and retention. Geographic region showed moderate relationships with most of the criteria. Schools located in the northeastern regions appeared to produce fewer officers with slightly higher than average scores on the AFOQT. Retention rates among these schools

Table 4

Predictor Variables: Means, Standard Deviations, and Zero-Order Correlations with Detachment Criteria
(N = 140)

Variable	M	SD	Correlations[a] AS300	Grads	CPG[b]	TDC[c]	AFOQT	Pilot	OER	Ret.
Institutional Subset 1										
Total male enrollment	5,583	4,021	41	41	-36	39	29	28	21	-03
Total enrollment	10,706	8,472	31	31	-29	28	26	24	19	-07
Av. ACT composite (freshmen)	23.44	2.68	-14	-10	06	-14	77	30	26	-60
Students per faculty member	17.03	5.67	11	08	-10	05	-21	01	-01	24
Geographic region										
New England	.043	.203	-14	-14	10	-14	10	-15	-18	-10
Mid-East	.136	.343	-18	-13	20	-14	28	-15	-19	-24
Great Lakes	.171	.377	-13	-09	07	-08	11	10	16	-01
Plains	.121	.327	-05	00	-01	-02	02	10	28	10
Southeast	.229	.420	13	14	-07	18	-15	-14	-08	09
Southwest	.114	.318	25	21	-18	22	-09	12	09	11
Rocky Mountains	.064	.245	06	04	-06	03	-15	09	-05	13
Far West	.121	.327	02	-08	-04	-12	-11	04	-09	-09
Institutional type										
University	.721	.448	20	25	-14	24	25	33	28	-32
Liberal arts college	.200	.400	-14	-20	16	-19	-24	-30	-21	18
Teachers college	.043	.202	-07	-08	-05	-08	-32	01	-19	34
Technical Institute	.036	.186	-09	-07	04	-07	26	-15	-02	00
Public control (1 = public)	.671	.470	37	33	-41	35	-16	27	13	26
Predominantly male (1 = male)	.179	.383	-03	00	11	01	37	-07	-04	-06
Institutional (Subset 2)										
Religious affiliation										
Nonreligious—Nonprofit	.150	.357	-21	-18	23	-17	23	-24	-18	-24
Roman Catholic	.093	.290	-21	-17	23	-18	08	-18	-06	-02
Other religions	.086	.280	-14	-14	16	-17	-11	04	08	-11

Table 4 (Continued)

Variable	M	SD	AS300	Grads	CPG[b]	TDC[c]	AFOQT	Pilot	OER	Ret.
			Correlations[a]							
Institutional Subset 2—cont.										
Average scholarship value	450	248	-25	-23	21	-21	48	-04	05	-47
Tuition per student	703	544	-39	-33	28	-32	36	-15	-02	-42
Percent on scholarships	16.18	12.93	-29	-29	33	-28	12	-05	-05	-16
Endowment—percent of revenue	75.68	18.79	40	37	-38	36	-06	18	00	14
Ph.D. awards per enrollment	.0064	.0077	04	05	-03	08	60	15	21	-43
Total revenue per enrollment	3,210	1,760	-06	-03	00	-03	47	07	04	-11
Institutional Subset 3										
Degree orientation (%)										
Realistic	15.26	16.94	20	22	-16	24	40	07	04	-11
Scientific	10.48	4.64	-19	-16	27	-16	34	-07	-07	-24
Social	31.27	13.21	-02	-06	-08	-06	-56	02	-01	29
Conventional	16.13	8.13	19	20	-19	18	-37	-14	01	28
Enterprising	12.62	7.90	-26	-26	29	-25	15	-04	-03	-17
Artistic	13.68	7.29	-27	-29	27	-31	07	-06	-01	-22
Aerospace	.53	1.09	24	25	-15	24	42	20	06	-20
Program										
Collocated ROTC (1 = coll)	.679	.467	27	29	-24	26	32	15	16	-26
Cross-town agreements (1 = yes)	.357	.479	-19	-21	24	-20	02	-09	-07	-09
Two- versus four-year curricula (1 = 2/4 year)	.914	.280	11	14	-09	23	19	12	20	-06

[a]Decimal points omitted.
[b]Cost per graduate.
[c]Total detachment cost.

were also slightly lower than for other regions. Conversely, schools from the southeast and southwest were good sources in terms of production and retention but were less likely to produce officers scoring in the higher ranges of the AFOQT.

The effects of institutional type and control were also quite divergent with respect to the enrollment, production, and retention criteria on the one hand and the aptitude and training performance and OERs on the other. Indeed, the general pattern of criterion relationships shown with these and the remaining variables underscores some of the difficulties faced by decisionmakers in the officer procurement area: By taking a course of action that may optimize performance in one area of concern, say, expected enrollment and productivity, it is likely that unacceptable decrements in program "effectiveness" may result in other areas (input quality) unless there is some basis for considering both factors simultaneously. While these data do not attempt to specify which criteria should be valued over others, they do suggest that a rational basis for judgment can be established taking into account various outcomes that may result from a given policy decision.

Institutional Effects

To explore the feasibility of estimating the criteria from combined knowledge of the institutional and program variables, regression analyses were performed on various subsets of the predictors. Table 5 shows the results obtained with the institutional characteristics in predicting the performance criteria. These data indicate that all three predictor subsets, when considered independently, contribute significantly to the prediction of the effectiveness criteria with only two exceptions. Multiple correlations for Subset 1, which included enrollment, average ACT, student faculty ratio, geographic location, institutional type and control, and the proportion of males to females in the student population, range from a low of .56 for the cost per graduate criterion to a high of .86 for AFOQT. Subset 2, which considered religious affiliation, average value of scholarships, percent of students on scholarships, revenue characteristics, and Ph.D.s awarded, yielded correlations in the range of .43 for total detachment cost to .68 for AFOQT performance. Degree orientations (Subset 3) were significantly related to all criteria with the exception of pilot training success and OERs. Overall, these findings suggest that an appreciable amount of variance in detachment criteria is attributable to institutional characteristics associated with the host college; these characteristics are beyond the control of AFROTC managers.

The question of whether information from all three data subsets

Table 5

MULTIPLE CORRELATIONS BETWEEN SELECTED PREDICTOR SUPSETS AND THE DETACHMENT CRITERIA

Institutional Predictor	Multiple Correlations							
	AS300	Grads	CPG	TDC	AFOQT	Pilot	OER	Ret.
Subset 1	.6219	.5948	.5685	.6138	.8607	.7205	.6555	.7139
Subset 2	.4730	.4547	.5205	.4341	.6777	.4352	.4718	.5923
Subset 3	.4077	.4173	.4055	.4152	.6645	.2938 NS	.1043 NS	.4329
Subsets 1 + 2	.6635	.6542	.6337	.6610	.8733	.7546	.6964	.7477
Subsets 1 + 3	.6663	.6484	.6222	.6583	.8714	.7473	.6679	.7229
Subsets 1 + 2 + 3	.6927	.6905	.6787	.6877	.8785	.7808	.7081	.7535
Subsets 1 + 2 + 3 + Program	.7003	.6979	.7128	.6962	.8815	.7881	.7288	.7623

NOTE: NS = nonsignificant; all other correlations significant at the .01 level.

would be required to make useful predictions was addressed in the following manner. The predictive accuracy associated with variables in Subset 1 was used as a baseline to evaluate unique contributions from Subsets 2 and 3 across all criteria. Results of these analyses, summarized in Table 6, indicate that in only one case was the accuracy of prediction obtained with Subset 1 variables improved to a significant extent with additional information. In the majority of comparisons, the predictability associated with Subsets 2 and 3 was shared in common with the baseline measures. There was some evidence that the degree-orientation data in Subset 3 contributed marginally to the prediction of the graduate production criteria. However, for the most part, the variables in Subset 1 yielded predictions that were equivalent to those obtained using Subsets 1, 2, and 3 combined.

Program Effects

Using institutional variables (Subset 1) as control measures, analyses were also made to determine if there were any unique effects on the performance criteria attributable to collocation with other ROTC units, cross-town agreements, or program length (two or four years). Regression equations containing both the institutional and program variables were compared with similar equations excluding the program variables across all criteria. If there were no differences in predictive accuracy associated with the full and restricted models, this would indicate that the program characteristics had little or no influence on the criteria when effects of institutional variables had been controlled. The results of these comparisons were somewhat equivocal, as shown in Table 7. The program variables taken in combination made unique contributions to only one of the eight criteria—unit cost per graduate. When each program variable was compared individually with restricted models containing *both* institutional variables and the remaining program variables, some evidence was found indicating that these factors may indeed have some unique influence on selected criteria. In these comparisons, collocation with other ROTC units was shown to have a significant effect on unit cost per graduate. Program length (two or four years) provided unique predictive contributions to the total detachment cost criteria, AFOQT, and OERs. The effect of cross-town agreements was negligible across all criteria.

An inspection of the raw score regression weights associated with these variables in the context of the institutional measures (Table 8) indicates that collocated detachments generally had a lower cost per graduate than did single detachments when institutional effects were held constant. The effects of collocation on AS300 enrollments, graduate production, and total detachment cost were in the expected direc-

Table 6

Effect of Institutional Characteristics—Regression Summary

Full Model		Detachment Criterion															
		AS300				Grads				CPG				TDC			
		R^2				R^2				R^2				R^2			
Source[a]	Restricted Model	Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F
Subset 1	Unit vector	.3868	.0000	17/122	4.53[b]	.3538	.0000	17/122	3.93[b]	.3231	.0000	17/1222	3.43[b]	.3766	.0000	17/122	4.34[b]
Subset 2	Subset 1	.4403	.3868	8/114	1.36[NS]	.4280	.3538	8/114	1.85[NS]	.4015	.3231	8/114	1.87[NS]	.4370	.3768	8/114	1.52[NS]
Subset 3	Subset 1	.4440	.3868	6/116	1.99[NS]	.4205	.3538	6/116	2.22[c]	.3871	.3231	6/116	2.02[NS]	.4333	.3768	6/116	1.93[NS]
Subset 2	Subsets 1 + 3	.4799	.4440	8/108	1.12[NS]	.4768	.4205	8/108	1.63[NS]	.4606	.3871	8/108	1.84[NS]	.4729	.4333	8/109	1.01[NS]
Subset 3	Subsets 1 + 2	.4799	.4403	6/108	1.49[NS]	.4768	.4280	6/108	1.68[NS]	.4606	.4015	6/108	1.97[NS]	.4729	.4370	6/108	1.32[NS]
		AFOQT				Pilot				OER				Ret.			
		R^2				R^2				R^2				R^2			
		Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F
Subset 1	Unit vector	.7409	.0000	17/122	20.51[b]	.5191	.0000	17/122	7.75[b]	.4297	.0000	17/120	5.32[b]	.5097	.0000	17/119	7.28[b]
Subset 2	Subset 1	.7627	.7409	8/114	1.32[NS]	.5695	.5191	8/114	1.66[NS]	.4850	.4297	8/112	1.63[NS]	.5590	.5097	8/111	1.55[NS]
Subset 3	Subset 1	.7593	.7409	6/116	1.49[NS]	.5585	.5191	6/116	1.73[NS]	.4461	.4297	6/114	.56[NS]	.5226	.5097	6/113	.51[NS]
Subset 2	Subsets 1 + 3	.7718	.7593	8/108	.74[NS]	.6097	.5585	8/108	1.77[NS]	.5015	.4461	8/106	1.47[NS]	.5678	.5226	8/105	1.37[NS]
Subset 3	Subsets 1 + 2	.7718	.7627	6/108	.72[NS]	.6097	.5695	6/108	1.85[NS]	.5015	.4850	6/106	.58[NS]	.5678	.5590	6/105	.35[NS]

[a]Subset 1 contains student enrollments, ACT scores, geographic regions, institutional type, private versus public control, and indicators of predominantly male representation. Subset 2 includes institutional religious affiliation, scholarship, tuition, and revenue variables. Subset 3 contains degree-orientation data.

[b]Significant at the .01 level.

[c]NS = Nonsignificant.

Table 7

Effect of Program Characteristics—Regression Summary

Full Model		Detachment Criterion															
		AS300				Grads				CPG				TDC			
		R^2				R^2				R^2				R^2			
Source[a]	Restricted Model[b]	Full	Rest	df	F	Full	Rest[a]	df	F	Full	Rest	df	F	Full	Rest	df	F
Prog. A + B + C	Subset 1	.4079	.3868	3/119	1.40^{NS}	.4352	.4205	3/119	1.03^{NS}	.3672	.3231	3/119	2.76^{c}	.4052	.3768	3/119	1.90^{NS}
Prog. A (ROTC)	Subset 1 + Prog. B + C	.4077	.3952	1/119	2.51^{NS}	.4352	.4223	1/119	2.72^{NS}	.3672	.3419	1/119	4.76^{c}	.4052	.4010	1/119	$.84^{NS}$
Prog. B (X-Town)	Subset 1 + Prog. A + C	.4077	.4039	1/119	$.76^{NS}$	.4352	.4335	1/119	$.36^{NS}$	.3672	.3532	1/119	2.63^{NS}	.4052	.4008	1/119	$.88^{NS}$
Prog. C (2 vs 4 yr)	Subset 1 + Prog. A + B	.4077	.4041	1/119	$.72^{NS}$	.4352	.4351	1/119	$.02^{NS}$	.3572	.3641	1/119	$.58^{NS}$	.4052	.3853	1/119	3.98^{c}
		AFOQT				Pilot				OER				Ret.			
		R^2				R^2				R^2				R^2			
		Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F	Full	Rest	df	F
Prog. A + B + C	Subset 1	.7541	.7409	3/119	2.13^{NS}	.5301	.5191	3/119	$.93^{NS}$	.4607	.4297	3/117	2.24^{NS}	.5219	.5098	3/116	$.98^{NS}$
Prog. A (ROTC)	Subset 1 + Prog. B + C	.7541	.7540	1/119	$.05^{NS}$	.5301	.5292	1/119	$.23^{NS}$	.4607	.4601	1/117	$.13^{NS}$	.5219	.5159	1/116	1.46^{NS}
Prog. B (X-Town)	Subset 1 + Prog. A + C	.7541	.7534	1/119	$.34^{NS}$	.5301	.5301	1/119	$.00^{NS}$	.4607	.4544	1/117	1.37^{NS}	.5219	.5218	1/116	$.02^{NS}$
Prog. C (2 vs 4 yr)	Subset 1 + Prog. A + B	.7541	.7418	1/119	5.95^{c}	.5301	.5196	1/119	2.66^{NS}	.4607	.4363	1/117	5.29^{c}	.5219	.5167	1/116	1.26^{NS}

[a]Program variable A—collocated ROTC. Program variable B—cross-town agreements. Program variable C—2 versus 4-year curricula.
[b]Subset 1 includes student enrollments, ACT scores, geographic regions, institutional type, private versus public control, and indicators of predominantly male representation.
[c]Significant at the .05 level.
NS = Nonsignificant.

Table 8

NET EFFECTS OF PROGRAM VARIABLES

Variable	Net Difference in Expected Value[a]							
	AS300	Grads	CPG	TDC	AFOQT	Pilot	OER	Ret.
Collocated ROTC								
Collocated	+5.9[NS]	+6.3[NS]	−2363[b]	+16810[NS]	+0.5[NS]	+0.87[NS]	+0.20[NS]	−3.05[NS]
Noncollocated	0.0	0.0	0000	0000	0.00	0.00	0.00	0.00
Cross-town agreements								
Yes	−2.2[NS]	−2.9[NS]	+1213[NS]	−11806[NS]	−0.8[NS]	−0.04[NS]	−0.45[NS]	+0.25[NS]
No	0.0	0.0	0000	00000	0.00	0.00	0.00	0.00
Program type								
2- or 4-yr	+4.0[NS]	+3.2[NS]	−1062[NS]	+45122[b]	+6.5[b]	+3.77[NS]	+1.61[b]	−3.60[NS]
2-year only	0.0	0.0	0000	00000	0.0	0.00	0.00	0.00
Criterion mean	26	25	10673	205002	65.7	76.82	34.16	48.44
Standard deviation	16	16	4445	76901	13.7	8.56	2.42	11.74

[a]Based on raw-score regression weights rescaled to an arbitrary baseline of zero.
[b]Significant at the .05 level.
NS = Nonsignificant.

tion but did not reach statistical significance. Collocation appeared to have negligible effects on the remaining criteria. Detachments with two- and four-year programs tended to have higher total detachment operating costs and were more likely to produce graduates obtaining higher scores on the AFOQT and the OERs than did comparable detachments offering only a two-year program. No significant differences were noted between the two types of program on the remaining criteria.

Cross-Validation Exercises

The results of the cross-validation exercises are presented in Table 9. In general, they suggest that prediction models developed on half-sample data maintained significant validity for all but one of the eight criteria when applied across both institutions and time. The inference is that these same properties would be found to an even greater extent in the full-sample equations. The only cross-validation in this set that failed to reach statistical significance was that associated with success in pilot training. Pilot training criteria may be unsuitable for assessment or forecasting purposes unless provisions are made to base completion rates on combined input over a minimum of three to five years. If used for forecasting purposes, the prediction systems associated with this criterion should be updated frequently. Cross-validities for the remaining criteria, while considerably shrunken, were statistically significant. It is important to remember that these estimates are conservative because the full-sample analysis included twice as many observations taken over time periods 1 and 2 combined.

Table 9

SPLIT-SAMPLE CROSS-VALIDATION

	Buildup[a]			Cross-validation[b]		
Criterion	Sample	Time Period	Multiple R	Sample	Time Period	Multiple R
AS300 enrollment	HS1	1970-73	.78	HS2	1973-75	.28[c]
Graduates	HS1	1970-72	.81	HS2	1972-74	.36[d]
Cost per graduate	HS1	1970-72	.73	HS2	1972-74	.30[d]
Total detachment cost	HS1	1970-72	.81	HS2	1972-74	.36[d]
AFOQT-OQ	HS1	1970-72	.89	HS2	1972-73	.48[d]
Pilot training comp.	HS1	1968-70	.68	HS2	1970-72	.14[NS]
Officer effectiveness	HS1	1968-70	.69	HS2	1970-72	.30[d]
Retention	HS1	1958-62	.80	HS2	1962-64	.34[d]

[a]Half-sample 1; criteria at time 1 (N = 73).
[b]Half-sample 2; criteria at time 2 (N = 67).
[c]Significant at the .05 level.
[d]Significant at the .01 level.
NS = Nonsignificant

APPLICATIONS

Current Detachments

The results of these analyses have various implications for evaluating detachments currently in the inventory. Not only could historical trends in unit production, costs, officer quality, and retention be monitored over time, it would also be possible to derive estimates of expected criterion performance based on differences in host-site characteristics. Given the large proportion of variance associated with these variables, a comparison of actual and predicted performance would provide a more equitable basis for judging the degree to which various units capitalize on available resources. The influence of factors beyond the control of individual detachment managers could be minimized in the quality control system. This concept is illustrated in Table 10, which compares discrepancies between actual and predicted performance on selected production and cost criteria for a number of detachments. Residual values have been provided indicating overperformance or underperformance, controlling for known differences in the predictor variables. Even though Detachments C and D each graduated 26 officers, Detachment C produced three more officers than would be expected on the basis of uncontrollable features of the environment, while Detachment D produced nine less than would be expected. In this case, Detachment C might be said to have capitalized to a greater extent on available resources than Detachment D.

Potential Host-Site Evaluation

The results of these analyses also have implications for the assessment of potential host-site institutions, as illustrated in Table 11. The institutional prediction equations are generalizable in theory to any prospective host site for which predictor information can be obtained. In this example, performance on selected criteria has been estimated for 15 schools not currently hosting AFROTC detachments. Expected values equal to or exceeding the average for current detachments are underlined. Of those listed, sites E and O might be considered among the most preferred locations. Sites C, G, and J would be least likely to support a detachment. The capacity for generating predicted scores for institutions that do not yet host AFROTC units will permit growth toward those schools offering the maximum potential for improving the officer force.

Table 10

COMPARISON OF ACTUAL AND PREDICTED CRITERION PERFORMANCE
BASED ON INSTITUTIONAL AND PROGRAM CHARACTERISTICS

	Grads			Cost/Grad (in thousands)			AFOQT			Retention		
Detachment	Actual	Predicted	Δ[a]	Actual	Predicted	Δ	Actual	Predicted	Δ	Actual	Predicted	Δ
Det A	60	45	+15	6.7	5.3	+1.4	30	50	−20	48	46	+2
Det B	53	35	+18	5.1	8.5	−3.4	70	80	−10	60	42	+18
Det C	26	23	+3	6.9	14.4	−7.5	40	35	+5	45	51	−6
Det D	26	35	−9	10.2	6.7	+4.5	65	40	+25	55	45	+10
Det E	55	34	+21	5.6	4.4	+2.2	55	20	+35	56	52	+4

[a]Difference between actual and predicted scores.

Table 11

EVALUATION OF POTENTIAL HOST SITES

Academic Institution	Predicted Performance			
	Grads	Cost/Grad (in thousands)	AFOQT	Retention
A	30	13.7	61	52
B	10	12.7	70	40
C	21	11.6	50	47
D	7	23.3	68	41
E	35	10.8	72	60
F	14	21.7	40	55
G	20	14.8	58	39
H	6	29.1	62	42
I	14	13.6	80	39
J	28	15.9	48	50
K	45	5.3	59	55
L	22	10.1	68	41
M	25	9.2	71	46
N	3	18.6	85	33
O	35	8.5	49	60
Av. for current detachments	25	10.7	66	48

NOTE: Underline indicates predicted performance at or above the average for current detachments.

SUMMARY AND CONCLUSIONS

The principal findings of this study may be summarized as follows:

1. Fairly stable differences between detachments were noted in AS300 enrollments, graduate production, total detachment cost, the proportion of graduates scoring above the 55th percentile on the AFOQT, and total officer retention. Mean intercorrelations across time (years) for these measures range from .53 (Retention) to .96 (Total Detachment Cost). The cost per graduate, OER, and pilot training success rates were somewhat less consistent over time, indicating that these criteria would require a longer time frame (a minimum of three to five years) on which to base a sound assessment. Moreover, they would require more frequent updating if used for long-range forecasting purposes.

2. A significant amount of the variance in the detachment effectiveness criteria could be attributed to institutional characteristics of

the host college largely beyond the control of detachment managers. These include student enrollments, average ACT composite, student/faculty ratio, geographic location, institutional type and control, and the proportion of males in the student population. Other factors were found to be related to the criteria but did not provide incremental validity in the presence of those factors already mentioned. The documentation of these relationships supported the feasibility of a comprehensive evaluation system applicable to both current detachments and potential host sites.

3. An analysis of the unique effects associated with program characteristics produced mixed results. When these variables were tested as a subset in the context of the institutional variables, significant differences were noted for only a single criterion: unit cost per graduate. A series of comparisons testing the unique contribution of each program variable in turn, however, indicated that collocated ROTC detachments tended to have lower costs associated with each graduate than did comparable detachments without collocated units. Relationships between collocation and enrollment, production, and total detachment costs were in the expected direction but failed to reach statistical significance. The presence or absence of cross-town agreements was insignificant for all criteria. Program type seemed to exert a moderate effect on three of the eight criteria: total detachment costs, AFOQT, and OER. In general, detachments offering *both* two- and four-year programs tended to have higher total detachment costs while also graduating officers with higher aptitudes and higher expected values on the OER.

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TECHNIQUES FOR INCREASING RETENTION OF NAVY ENLISTED PERSONNEL[1]

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In order to maintain adequate defense manpower in an all-volunteer environment, military policy and personnel management procedures must ensure that adequate numbers of qualified enlisted personnel are retained by the services. Techniques designed to increase retention and improve personnel satisfaction have been implemented by the Navy, in part through the Navy Career Counseling Program. Results of multi-phase research on these techniques are reviewed here.

Factors that influence retention and personnel satisfaction are also identified, including the social envelope, organizational climate, work environment, job satisfaction, individual attitudes and opinions, and attitudes of Navy wives. Effectiveness of techniques designed to increase retention and improve personnel satisfaction is discussed, along with the impact of research findings on Navy policy and personnel management procedures and implications for defense manpower policy.

INTRODUCTION AND BACKGROUND

In the era of the all-volunteer force, the military services must be capable of retaining adequate numbers of quality enlisted personnel to ensure our nation's defense. In general, reenlistment rates have been holding at acceptable levels. Recent military pay increases, reduced force strength requirements, and an unfavorable economy have

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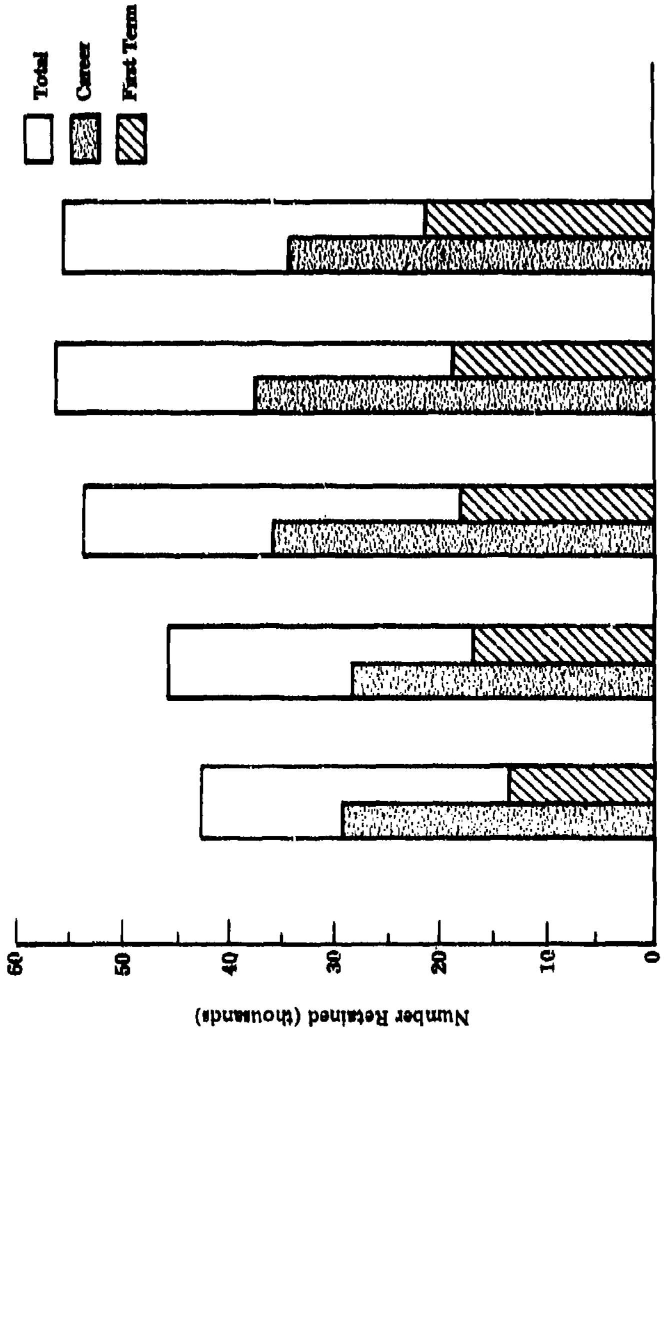
helped the services remain competitive with the civilian labor market. However, when the domestic job market improves, ensuring an adequate supply of manpower to meet military requirements may become a problem for all the services. Even today, some of the services are seriously concerned about certain aspects of retention. For example, the Navy is experiencing some imbalance in manning across pay grades and critical shortages in certain specialties. The need for quality personnel is accentuated by the growing requirement for expertise in the use of high-technology weapons systems. Inflationary pressures on military personnel costs mean that fewer dollars are available to acquire, train, and pay personnel. The manpower available over time for a given force strength is also decreasing because of increased attrition, defined as loss to the service before expiration of active obligated service. These are some of the reasons why techniques for increasing retention of enlisted personnel are important.

Need for Techniques To Increase Retention

The need to increase retention is often inferred from inspection of reenlistment rates. Certain difficulties arise, however, when these rates are used as the basis for inferring need. High rates do not necessarily mean that retention meets need. Comparisons of retention statistics from FY 1971 to FY 1975 point out some of the difficulties that may arise when reenlistment rates are used to establish need. One difficulty is that certain computations sometimes fail to reflect manpower supply directly. For example, Fig. 1 shows absolute numbers of Navy first-term and career enlisted personnel retained annually from FY 1971 through FY 1975. Total numbers increased through FY 1974, as did reenlistment of first-term personnel. However, career reenlistments tended to vary, with a peak being reached in FY 1974. Because the number of career personnel is larger than the number of first-term personnel, the total number tends to parallel the career number. Length of service gained as a result of reenlistment is also not reflected by these overall numbers. To assist in correcting this problem, the Navy has developed two Selective Retention Indicators[2] for measuring the effectiveness of command retention programs. First, the Head Count Figure of Merit is a decimal measure that compares the number of personnel who reenlisted with the number who separated and were eligible to reenlist, with ratios displayed by Career Reenlistment Objectives group. And second, the Manyear Figure of Merit is a decimal measure that compares *obtained* additional obligated service of those who reenlisted with *potential* additional obligated service. Potential is a maximum of six years minus the length of service remaining at the

[2] BUPERSNOTE 1133, 25 May 1974.



Number Retained	FY 71	FY 72	FY 73	FY 74	FY 75
Career	29,619	28,351	35,424	37,104	34,026
First Term	13,304	17,053	17,890	18,203	20,612
Total	42,923	45,404	53,314	55,307	54,638

Fig. 1—Numbers of personnel retained by Navy

time a reenlistment decision was reached. The first measure indicates the proportion of those eligible who reenlist; the second, the amount of manpower gained as a result of these reenlistments. Both measures are needed to make an accurate determination of the Navy's retention effectiveness.

Reenlistment rates for FY 1971 through FY 1975 are shown in Fig. 2. Comparison with Fig. 1 shows that trends based on rates tend to differ from those based on absolute numbers. For example, in FY 1974, the number of career reenlistments increased, whereas the reenlistment rate for these personnel dropped markedly. This demonstrates the importance of considering both absolute numbers and reenlistment rates in establishing the need for techniques to increase retention.

Another difficulty is that reenlistment rates vary depending on the method of computation. Three methods are normally used for computing Navy reenlistment rates:

(1) the *Department of Defense (DoD) formula*, which takes into account reenlistment, eligibility, and bonus extension:

$$\text{Reenlistment Rate} = \frac{\text{Reenlistments + Bonus Extensions}}{\text{Eligibles + Bonus Extensions}};$$

(2) the *Navy 4YO + 6YO formula*, which takes into account DoD formula variables and adds ineligibility as a factor in the denominator:

$$\text{Reenlistment Rate} = \frac{\text{Reenlistments + Bonus Extensions}}{\text{Eligibles + Ineligibles + Bonus Extensions}};$$

(3) the *Navy 4YO Only formula*, which excludes bonus extensions:

$$\text{Reenlistment Rate} = \frac{\text{Reenlistments}}{\text{Eligibles + Ineligibles}}.$$

For first-term personnel, FY 1971 through FY 1975 reenlistment rates computed using the DoD formula (17%, 23%, 23%, 32.9%, and 39.9%) were about twice as high as those computed using the Navy 4YO + 6YO formula (9%, 13% 14%, 19%, and 20.7%). Comparable rates computed using the 4YO Only formula (7%, 10%, 11%, 14.5%, and 15.9%) were even lower. For career personnel during the same time span, reenlistment rates computed using the DoD formula (90%, 91%, 92%, 80.3%, and 80.5%) were one-fourth to one-third higher than rates computed using the Navy 4YO + 6YO formula (59%, 61%, 69%,

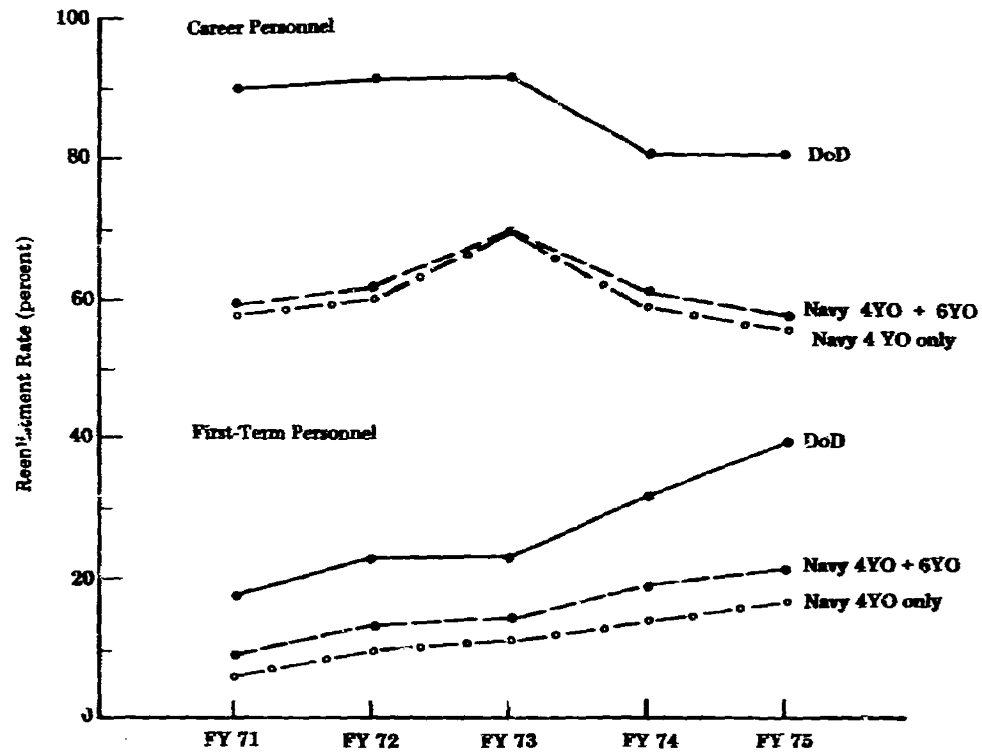


Fig. 2—Comparison of reenlistment rates computed by Dod and two Navy formulas

61.4%, and 57.7%) or the Navy 4YO Only formula (58%, 60%, 69%, 59.9%, and 56.1%). Use of the DoD formula caused reenlistment rates to be inflated over rates computed by the other formulas because ineligibility is excluded from the denominator. Inclusion of bonus extensions caused Navy 4YO + 6YO formula rates to be inflated over rates computed using the 4YO Only formula. Because bonus extensions reflect earlier commitments regarding length of service, including them tends to mask the need for techniques to increase retention. Therefore, the Navy 4YO Only formula appears to provide the most realistic estimate of need.

A further difficulty arises because loss of personnel through attrition is not clearly accounted for in the current computations. According to Navy statistics, in FY 1975 more first-term personnel were lost through attrition (25,726) than were retained through reenlistment and bonus extension (20,612). Less than one in four (24%) of those who left the Navy had a General Classification Test (GCT) score lower than 30, and more than one in three (34%) scored higher than 50. These figures indicate that a fairly large proportion might have been of potential benefit to the Navy had it been possible to retain them. In addition, financial resources committed to acquire and train such personnel were invested in assets that became unavailable to assist in accomplishing the Navy's mission.

A final difficulty arises because retention of quality personnel who have skills that are in short supply is not adequately reflected in overall Navy reenlistment rates. To assist in dealing with this difficulty, the Navy issues the quarterly Rating Health and Welfare Report. This report summarizes current manpower status for each rating, including Navy requirements, total inventory, distributable personnel and billets, numbers in training, career manning, criticality, first-term reenlistment information, sea/shore rotation, and special pay. This report is used to assist in monitoring and correcting any personnel imbalances that may occur.

In summary, the need for techniques to increase retention has tended to be obscured because overall reenlistment rates have been used to determine need. Official rates tend to vary depending on the method of calculation, with the most favorable rates being obtained using the DoD formula. To determine need, rates should be examined rating by rating, and the ineligibility factor and the masking effect of bonus extensions should be adequately taken into consideration.

Retention Criteria

Reenlistment intent, reenlistment decision, and performance have been used as criteria in research on retention. For example, motivational factors at various decision points during Naval service were investigated by Lockman, Stoloff, and Allbritton (1972). Data from an earlier survey of enlisted men, conducted by the Navy Personnel and Training Research Laboratory (Johnston, 1964; Malone, 1967) were reanalyzed. Results based on a sample size of 3,594, including unrated men and those in 11 critical ratings, indicate that "economic, psychological and personal characteristic variables all contribute to the prediction of reenlistment decision, . . . attitudinal as well as economic and biographical variables must be taken into consideration in maximizing the prediction of reenlistment intent" (Lockman et al., 1972, p. 38). However, the most important predictor of reenlistment decision was intent to reenlist.

Performance is also an important criterion in considering retention of quality personnel. Stoloff (1971) classified performance predictors on the basis of job content and job context variables, using the theoretical approach of Herzberg, Mausner, and Snyderman (1959). He found that *reenlistment intent* was predicted primarily by job context variables and *reenlistment decision* by reenlistment intent and job context variables. He also found that performance was primarily predicted by job content variables. Performance is also related to organizational practices, which have been found to be related to retention (Bowers, 1973; Drexler and Bowers, 1973). Job content, job context, and organizational practices need to be taken into consideration in the prediction of reenlistment of quality personnel.

The relationship between reenlistment intent and reenlistment decision was investigated by Holoter et al. (1974), using two reenlistment criteria, 12-month and 24-month increases in the date set for end of active obligated service. The 12-month criterion permitted comparison with results of an earlier study (Holoter et al., 1973); the 24-month criterion permitted comparison with official Navy statistics. As shown in Table 1, intent was a fairly good predictor of reenlistment for those who had made a decision about reenlistment. For those who were undecided, intent was a less effective predictor. The Phase 1 and Phase 2 samples were independent samples of Navy personnel serving in their first term of enlistment. Reenlistment intent was measured using responses of personnel on a career counseling survey, and reenlistment decisions of these personnel were determined through examination of records on the Navy Enlisted Master Tape.

As might be expected, the 24-month criterion lowered Phase 1 reenlistment rates for the three intent groups. For example, using a 12-month criterion, 94.1% of those who said Yes actually stayed in the Navy; using the 24-month criterion, 85.3% stayed. The decline in rate was greatest for the Undecided group.

The type of decision of primary interest to the Navy is the decision to reenlist. Figure 3, which compares intents of those who decided to

Table 1

Comparisons of Reenlistment Decisions with Intent for Independent Phase 1 and Phase 2 Samples of First-Term Enlisted Personnel
(In percent)

Reenlistment Decision	Phase	Reenlistment Intent Criteria: Yes, 12 months	Yes, 24 months	Undecided, 12 months	Undecided, 24 months	No, 12 months	No, 24 months
Stay in Navy	1	94.1	85.3	65.9	35.3	9.5	3.7
	2		92.9		57.6		4.1
Leave Navy	1	5.9	14.7	34.1	64.5	90.5	96.3
	2		7.1		42.4		95.9

NOTE: The initial Phase 1 sample N = 527 increased to N = 627 a year later; the Phase 2 sample was N = 218.

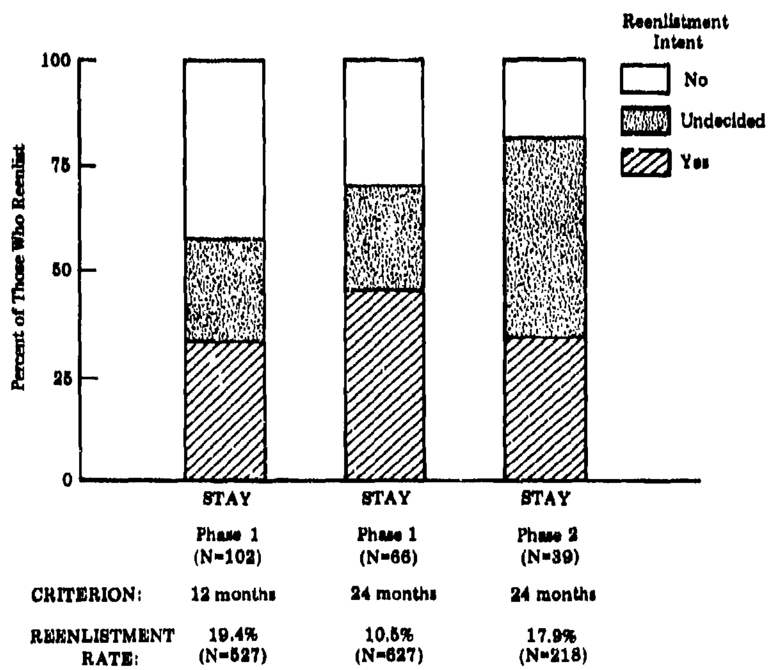


Fig. 3—Relationship between reenlistment decision and intent

stay in the Navy, shows that percentages vary. Using the 12-month criterion for the Phase 1 sample, the largest percentage (42.2%) of those who stayed in the Navy had an intent of No; using the 24-month criterion for the Phase 1 sample, the largest percentage (43.9%) had an intent of Yes. For the Phase 2 sample, the largest percentage (48.7%) were undecided. In all three cases the actual gain in manpower was less from those who said Yes than from the combined group of those who said No or were undecided. This finding indicates that techniques to increase retention should be designed to affect all enlisted personnel positively, regardless of their expressed intent.

TECHNIQUES TO INCREASE RETENTION

Several techniques to increase retention in the Navy have been implemented or are under development. The Navy Career Counseling Program is a major effort that is already under way. Research in support of this program conducted under the Navy Manpower R&D Program has resulted in the development of additional techniques.

Navy Career Counseling Program

The Navy Career Counseling Program is designed to obtain, on a long-term basis, a maximum number of highly qualified enlisted personnel for the Regular Navy. Emphasis is placed on obtaining personnel who are trained in occupations of critical importance, as well as those who have demonstrated proficiency in leadership and other occupations, regardless of criticality. This program forms a communications system designed to stimulate interest in the Navy, increase career motivation, encourage participation, and develop personal involvement that recognizes the potential, worth, and dignity of every individual in the Navy. Objectives are (1) to inform all personnel properly and adequately, (2) to provide effective career guidance that encourages individuals to make best use of their talents while in the Navy, (3) to increase goodwill and respect for the Navy toward the end of providing "ambassadors" for the Navy in the civilian community, (4) to encourage active participation in the Naval Reserve on separation, and (5) to aid in the identification and correction of problems at the local level.

The program is carried out through the Bureau of Naval Personnel, Fleet and Type Commands, and at the unit command level. To assist commanding officers in the execution of the program, primary duty career counselor billets were established at a ratio of one counselor per 750 members in each shore command with 400 or more members. Full-time, Bureau-controlled career counselors were assigned to most sea commands with 200 or more members, with additional billets assigned for each additional 750 members. These counselors are trained in BuPers-controlled Career Information and Counseling Course schools on the East and West Coasts. Training for collateral duty part-time counselors is also provided at Tycom Career Information Schools. Commands are encouraged to implement Command Retention Teams at the unit level to ensure active support and participation in the program and to increase awareness and involvement throughout the command.

To ensure that all personnel are counseled, three interviews are required under this program. First is the Reporting Interview, which is to be held within 30 days of reporting aboard and which includes counseling of wives or husbands, as appropriate. Second is the Retention Programs Incentive Interview, which is to be scheduled for the time frame of Active Duty Base Date plus 18 months. And third is the Incentives Program Interview, which is to be conducted 10 months prior to EAOS (End of Active Obligated Service) or PRD (Projected Rotation Date). These three required interviews are conducted with groups of enlisted personnel and are followed up by personal interviews to handle matters specific to individuals. Centrally provided support for the program includes a computerized monthly report designed to identify those personnel approaching EAOS or PRD who should attend the Incentives Program Interview. Other centrally produced aids are the Career Reenlistment Objectives list, which groups ratings on the basis of overpopulation, undermanning, or adequate supply, and the Rating Health and Welfare Report.

In addition, and as part of the program, the Navy has begun a retention advertising campaign, which includes a series of advertisements in the *Navy Times* and local Navy papers, coordinated with billboards placed at strategic locations near large Navy installations. Multimedia presentations have been developed for use in group interviews and with Navy wives, and a film has been prepared for use at the command level.

SDC's Research on Career Counseling

System Development Corporation conducted research in support of the Navy Career Counseling Program beginning in 1972. In Phase 1, the counseling process was analyzed (Meshi et al., 1972) and a survey was made of a sample made up primarily of first-term enlisted personnel, using a questionnaire especially designed for this purpose (Holoter et al., 1973). The sample was drawn from Navy units stationed in California, Virginia, and Hawaii. In Phase 2, the survey was administered to a sample of enlisted personnel in all terms of enlistment drawn from Navy units stationed at the same three locations (Holoter et al., 1974). Survey data from the first phase were reanalyzed and a technique for identifying target populations of Navy enlisted personnel receptive to reenlistment was also developed. In Phase 3, this technique was refined and factors influencing retention were identified (Grace et al., 1976).

Identification of Factors Influencing Retention. A quasi-experimental method was used to develop a technique to identify factors influencing retention. Hypotheses concerning reenlistment were generated and experimental tests, validations, and cross-validations were performed using independent samples of Navy enlisted personnel.

Samples were drawn from personnel surveyed in earlier phases of research (Holoter et al., 1974). In Phase 1, a sample of 1,711 first- and second-term enlisted personnel were surveyed in the fall of 1972, using a 253-item questionnaire especially designed for this purpose. This sample included 550 first-term personnel within six months of a reenlistment decision. In Phase 2, during the fall of 1973, the research was expanded to include a survey of 2,744 personnel in all terms of enlistment. Of these, 1,760 had served less than four years. Navy personnel records for these samples were obtained from Enlisted Master Tapes (EMTs) compiled in June of the years preceding and following each of the surveys. Records on these tapes were used to determine actual reenlistment decisions and to obtain information relative to hypotheses that had been generated.

Two independent samples, composed of first-term personnel who had the opportunity to make a reenlistment decision and for whom evidence of decision was available, were drawn from the personnel surveyed in Phase 1 and Phase 2. Separate data bases were built for each of these samples. The third independent sample, composed of Phase 2 personnel in terms of enlistment other than the first term and for whom the same evidence was available, was also drawn. A total of 898 personnel were included in these three samples. The actual reenlistment decision was determined by comparing the EAOS dates on two consecutive EMTs. Individuals for whom this date was

increased by at least two years were considered to have reenlisted. Individuals for whom EMT data were not available on a post-survey tape were considered to have left the service. These criteria followed established Navy policy. Thus it was possible to identify Stay (N = 142) and Leave (N = 756) groups, which together made up the set used to conduct this research.

Survey questionnaires and Navy personnel records were examined and seven categories of hypotheses were developed. The categories were Job, Vital Statistics and Economics, Self-Worth/Esteem and

Recognition, Growth and Expectancy, Family, Career Counseling and Information, and Recruiter/Retention. Hypotheses predictive of conditions under which individuals would be *more* or *less* likely to reenlist were generated for each of these categories, using prior research findings and experience with the Navy as the basis for generation. The procedure has been described in detail by Grace et al. (1976).

For each of the hypotheses generated, predicted reenlistment decision was compared against actual reenlistment decision. The Phase 1 sample of first-term personnel (N=627) was used for experimental testing of hypotheses. Findings were validated using the Phase 2 sample of first-term personnel (N=218). Fourfold tables were constructed and phi coefficients computed to determine degree, direction, and significance of relationships. The chi-square was used to test significance of the three-category intent-to-reenlist hypothesis.

Predictive power of groups of hypotheses was also determined. Distributions across categories were examined and like hypotheses combined to determine the ability of combined categories to differentiate between Stay and Leave groups. Category and total means for the Phase 1 and Phase 2 samples of first-term personnel were computed, compared, and cross-validated, using the sample of Phase 2 personnel in terms of enlistment other than the first term (N=53). One-way analyses of variance were computed to determine the significance of differences between means.

Results of the experimental test and validation of individual hypotheses that were confirmed ($p < .01$) are presented in Table 2. Hypotheses are identified by abbreviated short titles in this table. A prediction of *more* likely to stay in the Navy was made for all hypotheses except those followed by the word *Leave* in parentheses. For certain hypotheses, an Importance and Satisfaction (I/S) variable was created by combining extremes on these two measures. Percentages shown in the Stay and Leave columns reflect frequencies in the correct association diagonals of the fourfold tables. Over 150 hypotheses were generated and 32 were found to be significant predictors of reenlistment ($p < .01$).

Each hypothesis found to be a significant predictor identified an influencer of retention. Categories combined significant hypotheses into factors that influenced retention of first-term personnel. In descending order of number of significant predictors, these factors were Self-Worth/Esteem and Recognition, Job, Family, Career Counseling and Information, Economics, and Recruiter/Retention. Intent to reenlist was found to be the best single predictor of reenlistment. Growth and Expectancy did not appear to be a factor predictive of reenlistment of first-term personnel, using the criteria described above.

Category and total scores were obtained and compared across the

Table 2

Comparison of Percentages of Correct Association and Phi Coefficients Significant at the .01 Level of Confidence by Hypothesis Categories

Hypothesis Category	Hypothesis Short Title	Phase 1 Experimental Test: Stay (N=66)	Phase 1 Experimental Test: Leave (N=561)	Phase 1 Experimental Test: Phi	Phase 2 Validation: Stay (N=39)	Phase 2 Validation: Leave (N=179)	Phase 2 Validation: Phi
Job (N=6)	Present job interesting	58	72	.193	40	73	.182
	Likes being in Navy	59	87	.367	51	91	.427
	Feels abilities could be better utilized in civilian job (Leave)	45	82	.211	67	77	.357
	Likes Navy last six months	56	82	.286	46	84	.287
	No to Naval Reserves, through with Navy (Leave)	80	67	.302	82	64	.353
	Dissatisfied with present job assignment (Leave)	79	42	.129	87	40	.216
Economics (N=4)	Receiving VRB	70	68	.239	69	59	.214
	Incentives most attractive are Pro-Pay and VRB	52	68	.128	51	73	.197
	Receiving VRB would influence decision to reenlist	74	69	.279	85	60	.345
	I/S with amount of cash would receive as reenlistment bonus[a]	71	55	.162	62	64	.197
Self-Worth/ Esteem and Recognition (N=8)	Treated fairly in Navy	38	80	.131	38	84	.213
	Treated as individual human being	23	91	.134	33	88	.220
	Feels treated as person worthy of respect	38	85	.181	33	88	.220
	Wife not proud to be Navy (Leave)	44	86	.245	46	77	.201
	Good use of abilities in present job assignment	38	77	.109	44	78	.191
	I/S with extent feels useful in job	64	55	.113	79	58	.288
	I/S with recognition for doing a good job	65	63	.175	67	58	.186
	I/S with attitude of supervisor toward self and others	61	59	.124	72	54	.195

Table 2—continued

Hypothesis Category	Hypothesis Short Title	Phase 1 Experimental Test Stay (N=66)	Phase 1 Experimental Test Leave (N=561)	Phase 1 Experimental Test Phi	Phase 2 Validation Stay (N=39)	Phase 2 Validation Leave (N=179)	Phase 2 Validation Phi
Family (N=6)	Parents' (guardians') feelings about Navy negative (Leave)	91	23	.104	97	25	.212
	One or more dependents	55	65	.113	67	64	.241
	Spouse's feelings about Navy would influence reenlistment decision	50	75	.172	49	74	.187
	Accompanied by spouse	47	76	.164	61	78	.248
	Spouse most likes retirement benefits, dependent medical benefits, and Exchange and Commissary services	63	70	.153	49	74	.187
	Spouse least likes family separation, amount of money made, and changes of station (Leave)	44	32	-.153	46	30	-.196
Career Counseling and Information (N=5)	Career Counseling Program felt valuable	80	50	.168	67	43	.239
	Chats often with career counselor other than in interview	21	92	.133	31	89	.221
	Career counselor helpful in providing information	74	57	.193	69	66	.275
	During last interview discussed information of interest	65	63	.175	64	72	.292
	I/S with attitude of career counselor	68	51	.118	79	44	.181
Recruiter/ Retention (N=3)	Would encourage person to join Navy or point out pros and cons	77	51	.176	79	47	.205
	Intends to reenlist						
	Yes	85	15	260.54[b] df=2	93	7	111.26[b] df=2
	Undecided	35	65		58	42	
	No	4	96		4	96	
	Would reenlist if had to make decision today	48	98	.549	44	96	.486

[a]I/S stands for Important and Satisfied.

[b]Chi-Square.

three samples. Hypotheses reaching the .05 level of significance using the one-tailed test were grouped for purposes of these comparisons. All differences between Stay and Leave group means were significant ($p < .01$) for the two samples of first-term enlisted personnel. Results were cross-validated using the Phase 2 sample of personnel in terms of enlistment other than the first term. Categories found to cross-validate were Recruiter/Retention ($F = 50.397$, $p < .01$), Job ($F = 12.805$, p F .01), Economics, including vital statistics ($F = 5.138$, $p < .05$), and Self-Worth/Esteem and Recognition ($F = 4.007$, $p < .10$). Total score, which reflects overall career satisfaction, was found to cross-validate ($F = 7.298$, $p < .01$). Strength of feeling was also significant ($F = 7.922$, $p < .01$). These results indicate that intent to reenlist is the best predictor of reenlistment and that job, economics, feelings of self-worth/esteem and recognition, and overall career satisfaction are factors that importantly influence retention of Navy enlisted personnel.

These results suggest a number of possible tactics for positively influencing the reenlistment decision of undecided personnel. For example, techniques to increase satisfaction with job assignment, such as lateral transfer, job redesign, or job enrichment, could be expected to positively influence retention. In support of this suggestion, Haber, Ireland, and Solomon (1974) found that having a current billet different from the primary billet increased the probability of reenlistment among Marine Corps personnel. With regard to economics, receiving VRB was found to have a positive effect on reenlistment. The work of Haber and Stewart (1975) supports this finding. Stoloff et al. (1972) and Haber, Ireland, and Solomon (1974) also found that pay grade was a significant predictor of retention. La Rocco, Gunderson, and Pugh (1975) found that promotion to pay grade E-4 in a two-year enlistment or to E-5 in a four-year enlistment was a good predictor of reenlistment. Promotion rate and pay grade not only have economic implications, they provide status, which tends to increase feelings of self-worth/esteem and recognition among personnel. Haber and Stewart (1975) contrasted first-term enlistees' pay and promotion differentials among Navy occupations with those in civilian occupations and concluded that reenlistment mix could be improved by allocating a larger percentage of the higher ranks to those ratings with severe shortages of personnel.

Wives' attitudes toward the Navy are also a factor influencing retention of enlisted personnel (Lockman et al., 1972; Stoloff et al., 1972; Braunstein, 1972; and Holoter et al., 1973). Wives tend to favor reenlistment. In Phase 2 of this research, Holoter et al. (1974) found that 63.4% of the Navy wives surveyed were willing for their husbands to reenlist at the end of their terms of enlistment, and 69.9%

would encourage their husbands to reenlist if the decision had to be made immediately. In Phase 3, 53.4% were willing and 61.6% said Yes (Grace et al., 1976). These findings suggest the need to develop techniques that take advantage of the positive influence that wives' attitudes may have on husbands' reenlistment decisions. The importance of maintaining effective Navy Personal or Family Services Offices is also highlighted by these results.

With regard to career counseling, people appeared to be likely to reenlist if they felt that the Navy Career Counseling Program was of value to them, if they chatted frequently with career counselors other than in interviews, if career counselors were helpful in providing information and had recently discussed information of interest, and if the career counselor's attitude was felt to be important and was satisfactory. Therefore, techniques designed to assist counselors in discussing topics of interest to counselees might be expected to positively influence retention. The importance of ensuring that counselors master the necessary counseling skills also emerges from these findings.

In summary, techniques that favorably affect the reenlistment decision could probably improve retention of enlisted personnel. Many of these techniques could be carried out through existing channels at little or no additional cost to the Navy.

Techniques Under Development. As part of Phase 3 of SDC's research on career counseling, three techniques designed to assist in increasing the retention of Navy enlisted personnel were developed. Included were a Target Population Package, Command Retention Team Evaluation profiles, and a Navy Wives Contact Model. The Target Population Package was designed to identify enlisted personnel likely to reenlist. Career counselors using the package will ask each enlisted person to complete a questionnaire containing items found to be associated significantly with reenlistment decision. To ensure confidentiality, counselors will score the form in the presence of the enlisted person. Only a few aggregate scores will be retained by the counselor, and the questionnaire will then be given to the subject for his own use or destruction. This procedure is designed to prevent disclosure of personal information and to make sure that enlisted personnel filling out the form retain complete control over their own answers. Results will be discussed as soon as the form is scored, and additional interviews will be scheduled if the enlisted person so desires.

Command Retention Team Evaluation profiles were developed on the basis of interview and survey data and an analysis of records. The purpose of these profiles is to provide individual commands with increased capability to assess the effectiveness of their own retention efforts. Navy Human Resource Management Survey data were also found to be useful for assessment. Ownership of results resides with the command, and higher echelons within the Navy do not have access to findings unless the command wishes to send them forward. This procedure is designed to ensure confidentiality, to encourage open and honest address of problems, and to assist in the rapid solution of any problems within the command.

The Navy Wives Contact Model was designed to assist the Navy in providing wives with career information and assistance. Career counselors, members of the Command Retention Team, Personal and Family Services Offices, Housing Offices, Navy Wives organizations, and other Navy activities such as Navy Wives Information Schools were considered in developing this model. Largely as a result of research which led to development of the model, the Navy has placed increased emphasis on the importance of the family for retention. By making contacts such as those suggested by the model, the Navy hopes to take advantage of the positive influence that wives' attitudes may have on their husbands' reenlistment decisions and to increase overall satisfaction of all Navy personnel, including wives and families.

Additional Techniques for Consideration

Career Self-Development Model. Enlisted personnel who are career-motivated, in the general sense of the word *career*, appear to be more likely than others to reenlist. Although the cost of a full-scale program staffed by professional counselors would be too great to consider, a career self-development model designed to assist personnel in examining their own capabilities and career aspirations might well be feasible. A wide variety of counseling resources already exists within the Navy. If personnel could be motivated to make better independent use of these resources—for example, if they could be trained to work together in pairs—career motivation might be increased. If the Navy were to launch such a program, the very fact that the Navy officially encouraged life-long career self-development could be expected to increase morale and motivation of those participating in the program. Several types of career self-development programs are being carried out in the civilian world, some of which could probably be adapted for use in the Navy.

Command Retention Team Workshops. Supervisory recognition and command support for retention emerge as factors that have important effects on reenlistment. Workshops designed to assist Command Retention Team members in increasing their team-building skills and in improving organizational climate could be carried out through the Navy's Organization Development and Management Program, which is already in operation. The fact that the Division Officer is a key member of the Command Retention Team increases the probability that skills acquired would positively influence retention, because this officer is a member of the chain of command at a level close to the enlisted person. Additional workshops designed to improve interpersonal interaction and increase interviewing skills should also assist in increasing retention. These skills are addressed in the Career Information Counseling Course schools and reinforced by the command structure. However, refresher training and practice at the command level are still needed to ensure that adequate numbers of quality personnel reenlist. Workshops not currently in the inventory could be developed by Human Resource Specialists on a Navywide basis at minimal additional cost to the Navy.

Job Design/Enrichment. Feelings that personnel are doing useful and meaningful work also provide important motivation for reenlistment. Job design and job enrichment techniques already in civilian use might well be adapted for use in the Navy. These techniques could increase productivity, expand the scope of work performed, and increase the effectiveness with which it is performed. In addition, involvement in work tends to lead to greater individual commitment to organizational goals. This, in turn, would assist the Navy in accomplishing its overall mission.

Altruism/Patriotism Model. Feelings of personal worth and dignity were found to be positively associated with reenlistment. Such feelings also promote self-respect and commitment to the Navy as a whole. Traces of the highly negative attitudes toward the military common in the 1960s undoubtedly remain in the minds of enlisted personnel. An informational model stressing the altruistic and patriotic aspects of a Navy career could be developed as a part of the Navy's Organization Development and Management Program. This model would stress episodes in which Naval personnel and organizations behaved in a highly altruistic and patriotic manner that benefited other military personnel, civilians, and the nation as a whole. By placing emphasis on pride in the Navy as expressed through the personal sphere of individuals' lives, this model could assist in counteracting negative feelings about a military career.

Family Sponsor Program. Wives' attitudes clearly influence reenlistment. The concept of a Family Sponsor Program[3] is designed to influence junior wives' attitudes positively toward the Navy. It would involve the pairing of a senior Navy family with one or more junior families to provide the reinforcement and personal support that are present when such families live close to their relatives. Frequent moves to locations populated by strangers are characteristic of Navy

[3] This concept differs from the existing Sponsor Program for transferring personnel in that families would be involved on a continuing basis.

life. This life style is very different from that experienced by young families in the civilian world. Navy Wifeline and other wives' organizations attempt to fill this gap. However, these resources are external to the Navy chain of command, and it is difficult to muster them on any basis other than a request for assistance. By developing a formal Family Sponsor Program authorized through the chain of command, personal satisfaction of junior enlisted families could probably be improved and in turn could be expected to serve as a positive influence on reenlistment.

Wives' Education/Training. Navy wives, particularly wives of junior personnel, often need or want additional education or training. For the Navy to carry out an educational program for wives singlehandedly would be very costly; however, other fairly economical techniques are possible. For example, courses at local high schools, junior colleges, and other institutions of higher education could be made available to wives at very low cost. Using the Navy Wives Contact Model, career counselors and other Navy personnel could encourage wives to take advantage of such opportunities. Extension courses dealing with homemaking, child care, and family finance could be scheduled at Navy locations and wives could be similarly encouraged to attend. These latter courses might be extremely beneficial to younger Navy wives, many of whom are setting up housekeeping for the first time, often at great distances from their friends and family. And finally, where there are Navy schoolrooms, it might be useful to explore the possibility of making empty seats available at a nominal cost to Navy wives living in the area. All of these techniques are possible ways to increase personal satisfaction of Navy wives who are interested in furthering their education or training.

Increased Travel and Housing Benefits for Families of Junior Enlisted Personnel. Navy travel and housing regulations tend to favor the families of enlisted personnel in pay grades E-4 and above. This falls in the area of Navy policy and has financial implications. However, junior enlisted personnel are more likely to reenlist when they can be accompanied by wives. Although study would be required before possible changes could be identified and carried out, it might be useful for the Navy to consider changing these regulations, especially for personnel in critical specialties or whose quality is such that the Navy would like to retain them as career members of the service.

Improved Housing for Unmarried Enlisted Men. The group of enlisted personnel most dissatisfied with Navy life and least likely to reenlist is that of single men in the lower pay grades. Married personnel of equivalent pay grade have their incomes augmented through allowances. This augmentation creates a pay differential between groups performing essentially the same work, which seldom if ever exists in the civilian work world. In essence, Navy personnel are paid on the basis of family size rather than strictly on the basis of work performed. The economic factor has an important influence on reenlistment and motivation on the job. Receiving money for reasons other than work performed tends to be a disincentive for those not entitled to receive it—in this case, the single enlisted man. Having shipboard quarters as their only home while on sea duty also tends to demotivate unmarried enlisted men. An alternative might be to provide single enlisted men assigned to sea duty with housing on shore when they are in port. Although this also falls in the area of Navy policy and has financial implications, it deserves serious consideration because of the large numbers of first-term single men who separate from the Navy each year.

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THE RELATIONSHIP BETWEEN AIR FORCE ACADEMY CADET PERFORMANCE AND OFFICER PERFORMANCE[1]

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A battery of predictors are compared with retention and various officer performance criteria for officers who graduated from the Air Force Academy in 1964 and 1965. Three main categories of predictive measures are studied: (1) high-school academic, athletic, and leadership performance; (2) four years of Academy academic and military performance; and (3) various personality measures collected during the officers' first year at the Academy. Officer performance measures studied are (1) below-the-zone promotions, (2) awards and decorations, (3) officer effectiveness ratings, and (4) flying training grades, where applicable.

This study assesses the relative predictive validity of the various sets of predictors and, for the class of 1965, the relative validity of peer and superiors' ratings of performance during the final year at the Academy. Statistical techniques used in this study include regression analysis and the Automatic Interaction Detector.

[1] This research was made possible through the efforts of a number of people, whose contributions are gratefully acknowledged: Captain John Gardner, for extensive programming assistance; Betty Roth, Betty Branum, Delores Thomas, and Lillian Anaya, for tireless data reduction and compilation. The original data from this study would not have been collected and saved without the leadership and foresight of Ris Westen and Lt. Col. Cary Thompson.

[2] The author is on active duty. Views expressed in this paper are his own and do not necessarily reflect those of the Department of Defense, the United States Air Force, or the United States Air Force Academy.

INTRODUCTION

Managing the officer force requires careful attention to both retention on active duty and job-related performance. Although graduates of the Air Force Academy constitute only a small portion of the Air Force officer force, they are increasing in numbers and beginning to hold jobs of greater responsibility. Because of the cost of producing graduates and because of the role they will assume in Air Force leadership, their retention and their performance on active duty are of considerable interest to Air Force personnel managers. This paper focuses on these two aspects and seeks to understand which characteristics of young men entering the Academy in 1960 and 1961 are related to their performance in the Air Force. The ultimate criterion for assessing the effectiveness of service academy training efforts is not performance of young men while at the Academy but their service on active duty after graduation. It is hoped, of course, that there is a relationship between good performance at the Academy and good performance in the Air Force.

In many respects, this study is similar to others that have analyzed the relationships among occupational mobility, job performance, and leadership and prior measures of academic ability, extracurricular activities, athletic activities, and personality variables. Research in this area emanates from two diverse groups: personnel and management researchers interested in predicting managerial performance, and labor economists analyzing various aspects of human capital theory. In the former group, Harrell (1961, 1969), Cummings (1966), Mahoney, Jerdee, and Nash (1960), and Kraut (1975) are representative of the managerial or behavioral approach. Korman (1968) provides a comprehensive review of most studies using this approach. Economists interested in the returns of human-capital investment are well represented by the research of Gintis (1971), Griliches and Mason (1972), and Wise (1975).

Studies on military populations are few. Janowitz (1960) analyzed the socioeconomic background of military leaders as well as the various motivations that direct a person toward a military career. Zald and Simon (1964) also studied the factors associated with commitment to a military career. Ewing and Alvord (1965) and Kaapke, Tupes, and Alvord (1965) analyzed Air Force officer career attitudes and the background and motivational factors most closely related to career intent. Norman (1971) compared the attitudes and backgrounds of Army officers who stayed on active duty with those of officers who had left active duty and were serving in reserve units. Hollander (1965) assessed the relationship between peer nominations during Officer Candidate School and performance ratings of Naval officers who had been on active duty at least three years.

The training function of military academies is well known. Closely related to training is the socialization function. Socialization refers to the process by which a new member of an organization learns the attitudes and values relevant to the organization he is entering (Schein, 1967). Lovell (1964) studied aspects of the socialization process at the United States Military Academy, though he did not relate socialization to subsequent performance on active duty. Both the training and socialization processes that academies conduct are intended to produce good officers. A basic premise is that those who are effectively integrated into the Academy environment are more likely to stay on active duty and perform at higher levels in their active service. Effective socialization into the Academy is first a function of the background and abilities, both academic and leadership, that a young man brings to the Academy from high school. Second, socialization can be inferred from a cadet's performance in academics and military duties while at the Academy. This performance is continually evaluated, and it is rewarded when it exceeds certain levels.

The basic hypothesis guiding this research is that effective socialization into the Academy environment as measured by the person's performance at the Academy is directly related to subsequent retention on active duty and performance in his Air Force duties. Korman (1968) reviews several studies conducted on graduates of the Military and Naval Academies in the 1950s. Detailed studies have not been conducted to test this hypothesis for Air Force Academy graduates, but such studies are appropriate to validate the Academy's training philosophy, procedures, and reward system, and to gain insight into possible modifications of current training programs at the Academy.

METHODOLOGY

Population

To assess the factors that best predict officer retention and performance, the classes that graduated in 1964 and 1965 were selected for detailed study. These classes were selected because both had sufficient history since graduation (11 and 10 years) for retention and performance behavior to stabilize, both were fairly large classes (499 and 517 graduates),[a] and extensive data on high school and Academy performance were readily available. Table 1 summarizes key statistics on these two classes. Only those graduates commissioned in the Air Force are included in this study.

[a] Fewer than 300 people graduated from each of the first four Academy classes (1959 to 1962).

Table 1

SUMMARY DATA ON CLASSES OF 1964 AND 1965

Student Status	Class of 1964	Class of 1965
Entered Academy	780	801
Left Academy before graduation	281	284
Total graduated	499	517
Commissioned in the Air Force[a]	495	507
Left active duty	207	210
Still on active duty (as of 1 Sept. 75)	288	297

[a]Some graduates were not commissioned in the Air Force because they were not medically qualified or because they were commissioned in other services.

Independent Variables

While these two classes were at the Academy, a large number of variables were developed and retained that could be possible predictors of subsequent Air Force retention and performance. Main categories of predictor variables are summarized below.

1. High school academic performance measured by:
   a. Grade point average (GPA) broken out by science and nonscience, freshman-sophomore, junior-senior, and four-year cumulative.[4]
2. Selection scores for entrance to the Academy:
   a. Four College Entrance Examination Board scores.
   b. Measures of leadership potential—physical aptitude examination, athletic activities index, and nonathletic activities index.[5]

[4] All grade point averages in this research are computed by dividing total quality points by total credit hours where A, B, C, D, and F grades are worth 4, 3, 2, 1, and 0 points, respectively.

[5] The physical aptitude examination was administered to Academy candidates as part of the admission process. For the classes of 1964 and 1965, scores on five events—hurdle run, medicine ball throw, chin-ups, 300-yard shuttle run, and vertical jump—were aggregated to form this variable. The athletic activities index was based on candidate-supplied data concerning participation in high school athletics. Higher scores are assigned on this index to the extent that the person participates in organized sports and team contact sports, is captain or co-captain of a team, or receives All-State or All-Conference recognition. The nonathletic activities index, constructed in a similar manner, is higher to the extent that the person was elected to high school student government or class offices, held an office in student clubs and activities, or participated in high school and community activities and clubs.

3. Scores from Graduate Record Examinations taken each year at the Academy (four years for class of 1965—12 scores; three years for class of 1964—9 scores).
4. Academic performance at the Academy measured by:
   a. Academic standing for each of four years at the Academy.[6]
   b. Science, nonscience, and total GPA for each of four years at the Academy and four-year cumulative science, nonscience, and total GPA.
   c. Cumulative GPAs for courses in each of 15 academic departments and each of four major academic divisions (engineering sciences, basic sciences, humanities, and social sciences).
5. Military performance at the Academy measured by:
   a. Extracurricular activities score and military rating score in each of four years at the Academy (classes of 1964 and 1965).[7]
   b. Peer rating average, Air Officer Commanding (AOC) rating, extracurricular activities score, physical fitness test score, and conduct score in fall and spring semesters of senior year (class of 1965 only).[8]

[6] Academic standing was determined by aggregating academic quality points, weighted 75 percent, and academic grade point average, weighted 25 percent. Both were converted to a standard score with a mean of 500 and a standard deviation of 100 before aggregation.

[7] The extracurricular activities score was based on the cadet's participation in cadet clubs and committees, varsity, junior varsity, freshman athletics, cadet choirs, and the debate team. The military rating for the four years that the class of 1964 and the first three years that the class of 1965 attended the Academy was based on the evaluation of the officer in charge of each cadet squadron, the Air Officer Commanding (AOC). The AOC rank orderings of cadets in each squadron were then merged across all squadrons to determine the class military order of merit. The scores used in this research for both extracurricular activities and military order of merit are standard scores with a 500 mean and 100 standard deviation.

[8] In the class of 1965 senior year, the military rating system was modified to include several components:

1. *Peer rating average.* Every cadet rank-ordered his peers on a scale from 1 to 60, with 1 being the best score. These ratings were then averaged for each cadet.
2. *AOC rating.* Each AOC rank-ordered the cadets in each class in his squadron on a scale of 1 to 60, with 1 being the best score.
3. *Extracurricular activities.* A score was developed on each cadet in a manner similar to that described in footnote 7.
4. *Physical fitness.* Each cadet was tested by the Physical Education Department with his scores on chin-ups, sit-ups, push-ups, standing long jump, and 600-yard run aggregated to form a composite physical fitness score.
5. *Conduct.* The number of demerits received by each cadet was standard scored and transformed to reflect higher scores as indicative of better conduct or fewer demerits.

The standard scores for each component were then combined to form the military order of merit. In this research, only the five components are analyzed.

Dependent Variables

Three dependent variables were studied. The first is loss rate from active duty as of September 1975. All losses from active duty are coded as a 1, with graduates still on active duty being coded a 0. Different types of losses are not differentiated in this analysis. Approximately 79 percent of all active duty losses for these two classes were voluntary resignations. The remaining losses were involuntary separations, medical retirements, and deaths.

For those still on active duty, two performance measures were analyzed. One is based on the officer's last five effectiveness ratings.[9] The standard Officer Effectiveness Rating (OER) mean covering the last ten ratings was not readily available. Because the distribution of effectiveness ratings is very skewed, with many people receiving the maximum performance rating of 9 on a scale of 0 to 9, there is little variance in these data across officers. Therefore, performance data were transformed to a binary variable using the following rule: If an officer had a 9 for each of his last five ratings, he was assigned a 1. If he had at least one rating less than 9, he was assigned a 0.[10]

The second performance measure is based on early selection to the rank of major. Officers promoted earlier than the modal promotion date for their peers were assigned a 1; all other officers were assigned a 0.

Statistical Method

A number of statistical analysis techniques were considered. Because it was expected that the relationships might be quite complex and because there was no a priori model describing the relationships, we used the Automatic Interaction Detector (AID), a multivariate technique developed by Sonquist and Morgan (1964), to explore the data described above. This technique (see also Morgan and Sonquist, 1963) has been used in a variety of research (e.g., Taylor and Wilsted, 1974; Utterback, 1975) where interaction and curvilinear effects might be expected and where the many independent variables may be measured on only nominal or ordinal scales. As Sonquist and Morgan (1964, pp. 1, 4) explain the procedure:

[9] The Officer Effectiveness Rating (OER) is the annual performance report completed on each active duty officer by his immediate supervisor. Although a number of specific job behaviors are rated by the supervisor, only the composite rating on a scale of 0 to 9 was available for use in this research.

[10] When an officer had training reports (reports issued in lieu of a performance rating when an officer is in school) one or more times for the last five reporting periods, the same rule was used. Thus, some officers were assigned a 1 with less than five 9s so long as the other ratings were training reports.

> Linearity and additivity assumptions inherent in conventional multiple regression techniques are not required.... The program divides the sample, through a series of binary splits, into a mutually exclusive series of subgroups. Every observation is a member of exactly one of these subgroups. They are chosen so that at each step in the procedure, their means account for more of the total sum of squares (reduce the predictive error) than the means of any other equal [number] of subgroups.

Several options are available for selecting groups to split, for dividing a predictor into two nonoverlapping subgroups, and for stopping the splitting process. In the analysis reported here, the following rules were used: A group did not become a candidate for splitting unless the total sum of squares for that group around its own mean was larger than 1 percent of the original total sum of squares around the grand mean and the group contained more than 30 observations. To minimize the proliferation of splits and the creation of groups that may be simply artifacts of random variation in the data, the splitting process was terminated when 25 groups were created. Where data are missing on any one variable entered in the analysis, the program deletes the observation.

A limitation of the program is that an independent variable cannot have more than 63 values. Thus, it was necessary to collapse a number of the predictors into subcategories. To ensure that the size of subcategories did not get too small, most predictor variables were collapsed into five subcategories. Table 2 summarizes the rules used in these transformations. The intervals in Table 2 were chosen to distribute the total population across the five categories in roughly equal numbers. Since the distribution in each subgroup changes after each

Table 2

COLLAPSING OF INDEPENDENT VARIABLES INTO CATEGORIES[a]

Variable	Category 1	2	3	4	5
Entrance scores and GREs	200-474	475-549	550-624	625-699	700-800
Grade point average	0-1.99	2.00-2.49	2.50-2.99	3.00-3.49	3.50-4.00
Military and academic performance standard scores (500 mean & 100 standard deviation)	100-399	400-474	475-549	550-624	625-950
Peer ratings and AOC rating	1-11	12-23	24-35	36-47	48-60

[a]On all variables except peer and AOC ratings, higher scores indicate better or organizationally preferred performance, abilities, or aptitude.

step in the splitting process, it was considered unnecessary to establish rigorous intervals for each variable to ensure a uniform distribution for only the first split. Although no sensitivity analyses were undertaken in this research, the splitting process may be sensitive to the actual intervals used.

There are several alternatives available for displaying the results of the analysis. This research uses tree diagrams that trace the splits made on each group. These diagrams assist in visually following the splitting process and tracing backward to each subgroup's origination. Final groups that were not split further are indicated with an asterisk.

FINDINGS AND ANALYSES

Because of the large number of possible predictor variables, the analysis of the data proceeded through several stages, the first being a search for those variables that appeared to be the best predictors of the dependent variables. For each of the three dependent variables using data from the class of 1965, the AID was used to search each of six subsets of independent variables, which were identified on the basis of the type of performance being measured or the type of instrument used to measure the ability or aptitude. These subsets correspond to the five major categories of independent variables, with Academy academic performance identified by yearly GPAs and departmental GPAs. Variables in each subset that accounted for 1 percent or more of the total variation in the dependent variable are listed in Table 3. Also shown in Table 3 is the multiple correlation coefficient for each of the analyses.

There is some indication of the relative predictive strength of each set of independent variables. High school academic performance measured by GPAs is only weakly related to active duty loss rates and early promotions and not related at all to effectiveness ratings. Scores used in the Academy admission process are not related to loss rates, weakly related to effectiveness ratings, and fairly strongly related to early promotions. Graduate Record Examination scores and military performance at the Academy are weakly related to loss rates but more strongly related to effectiveness ratings and early promotion. Academic performance at the Academy measured by yearly and departmental GPAs is fairly strongly related to all three criteria, though the strongest relations occur for officer effectiveness ratings.

The analyses summarized in Table 3 helped identify the key variables in each subset. These variables from each subset were then entered in a composite analysis to further explore the relative importance of each variable as well as the interactive pattern across the

Table 3

SUMMARY OF MAIN PREDICTORS OF RETENTION AND PERFORMANCE WITHIN SUBSETS OF INDEPENDENT VARIABLES: ACADEMY CLASS OF 1965

Independent Variable Subset	Dependent Variable: Loss Rates	Dependent Variable: Effectiveness Rating	Dependent Variable: Early Promotion
High school GPAs	Rank in H.S. class H.S. total GPA (r = .15)	No predictors	Rank in H.S. class H.S. Freshman-Soph total GPA H.S. Freshman-Soph nonscience GPA (r = .24)
Academy Entrance scores	No predictors	CEEB English composition (r = .12)	CEEB English comp CEEB math achievement Athletic activities index Nonathletic activities index (r = .44)
Graduate Record Exam scores	GRE quant (Jr yr) GRE soc sci (Soph yr) GRE humanities (Sr yr) GRE soc sci (Sr yr) (r = .25)	GRE soc sci (Soph yr) GRE nat sci (Soph yr) GRE engineer (Jr yr) GRE nat sci (Sr yr) GRE humanities (Sr yr) (r = .49)	GRE soc sci (Fr yr) GRE humanities (Soph yr) GRE humanities (Sr yr) GRE soc sci (Sr yr) (r = .44)
Academy Military Performance	Physical fitness (Sr spring) Conduct score (Sr spring) Excurr activities (Sr fall) Conduct score (Sr fall) Grad order of merit (r = .27)	Mil. rating (Fr yr) Peer rating (Sr fall) Conduct score (Sr spring) Physical fitness (Sr spring) Leadership composite (Sr) (r = .49)	Mil. rating (Fr) Peer rating (Sr fall) Conduct rating (Sr fall) Peer rating (Sr spring) Officer rating (Sr spring) Grad order of merit (r = .48)
Academy Academic performance, Part I--yearly GPAs	Academic standing (Sr) Science GPA-total Academic standing (Fr) Science GPA (Fr) (r = .36)	Total GPA (Sr) Academic standing (Sr) Total GPA (Soph) Total GPA (Fr) Nonscience GPA (Fr) (r = .43)	Academic standing (Sr) Academic standing (Jr) Nonscience GPA (Jr) (r = .31)
Academy Academic Performance, Part II--departmental GPAs	GPA foreign lang GPA law GPA behavioral sci GPA military train GPA engineering science[a] GPA chemistry GPA humanities[a] (r = .44)	GPA English GPA physical ed GPA chemistry GPA physics (r = .48)	GPA military train GPA aero GPA English GPA physics (r = .38)

NOTE: Sr = Senior; Jr = Junior; Soph = Sophomore; Fr = Freshman. Numbers in parentheses are multiple correlation coefficients. This number squared indicates the portion of the total variance of the dependent variable that is explained by the groups generated by the AID. Additional details on each of the 18 analyses summarized in this table can be obtained from the author.

[a]Divisional GPAs for all courses in the particular academic division.

various subsets of variables. Those variables used in the composite analysis for the class of 1965 were also used with the class of 1964 to test the generalizability of the class of 1965 results.[11]

Because some of the variables used for the class of 1965 were not available for the class of 1964, it was not possible to conduct a true cross-validation of the model developed on the class of 1965. Rather, the pattern of interactions from the 1964 analysis was judgmentally compared with the pattern from the 1965 analysis. The comparison of the two classes focused on the early splits and on which types of variables tended to be dominant.

There are other reasons why the tree diagrams for the two classes may differ: (1) With small sample sizes, as used in this research, there is a likelihood of sampling instability producing what Sonquist and Morgan (1964) call idiosyncratic splits. Such splits are more likely to occur toward the end of the splitting process. (2) Differences between the two classes may simply be due to the composition of the classes, different training received at the Academy, and different experiences and assignments on active duty, including exposure to the Vietnam conflict. In assessments of the generalizability of the findings, results are more reliable when the same variable or type of variable occurs in early splits for both classes and, where splits are made, the means of the new groups have similar relationships to one another in both classes.

The remainder of this discussion summarizes the composite analysis for each of the three dependent variables for the classes of 1964 and 1965.

Prediction of Loss Rates

The results of the composite analysis of loss rates are presented in Fig. 1 for the class of 1965, and Fig. 2 for the class of 1964. These figures show the splits that were made on each group, starting with the total group. Shown for each group are the variables on which it was split, the subcategories of the variable that forms the two new groups, the mean loss rate, and the population for each of the two new groups. All the variables in the analysis are shown in Table A.1 of the Appendix.

The information in Fig. 1 can be used for a brief description of the algorithm used by the AID. The total group of 451 graduates having no missing data on the variables included in the composite analysis was first searched over all predictors to find a split of the total sample to maximize the between-group sum of squares for the two new

[11] For the most part, the same data base existed for the two classes, the main exception being military performance data for the officers' senior year at the Academy. See footnotes 7 and 8 for details on differences in military performance data.

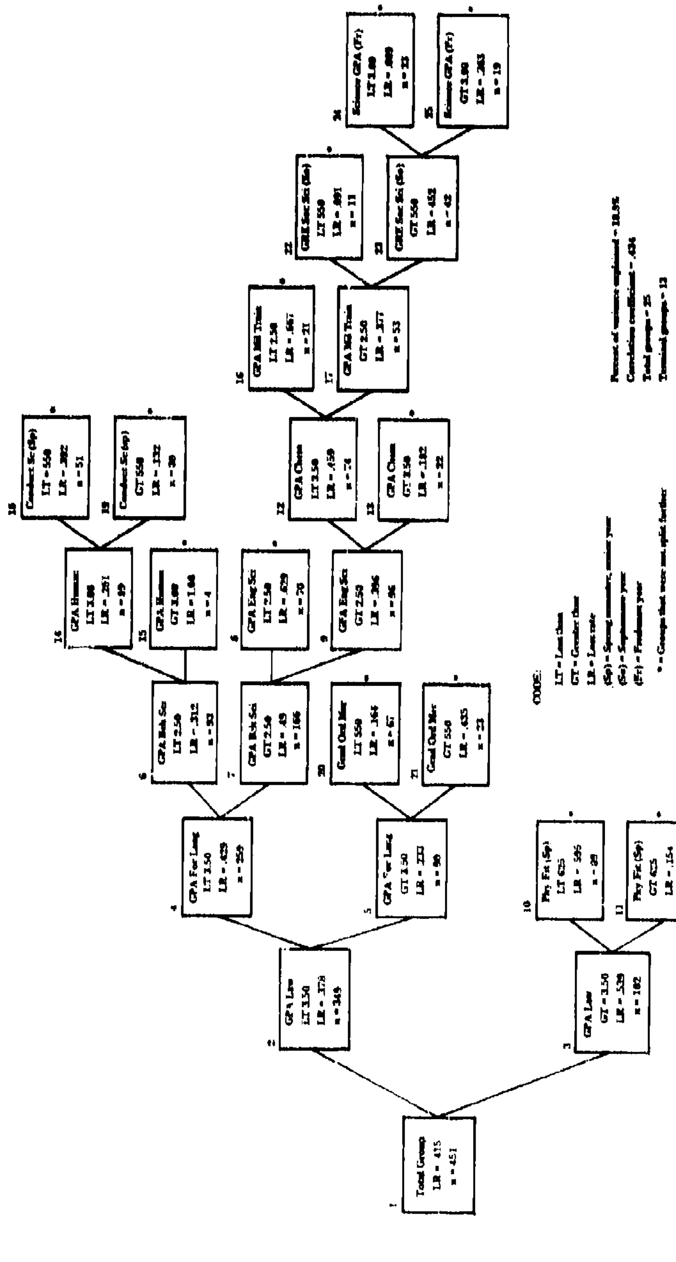

Fig. 1—Automatic Interaction Detector analysis of loss rates—class of 1964

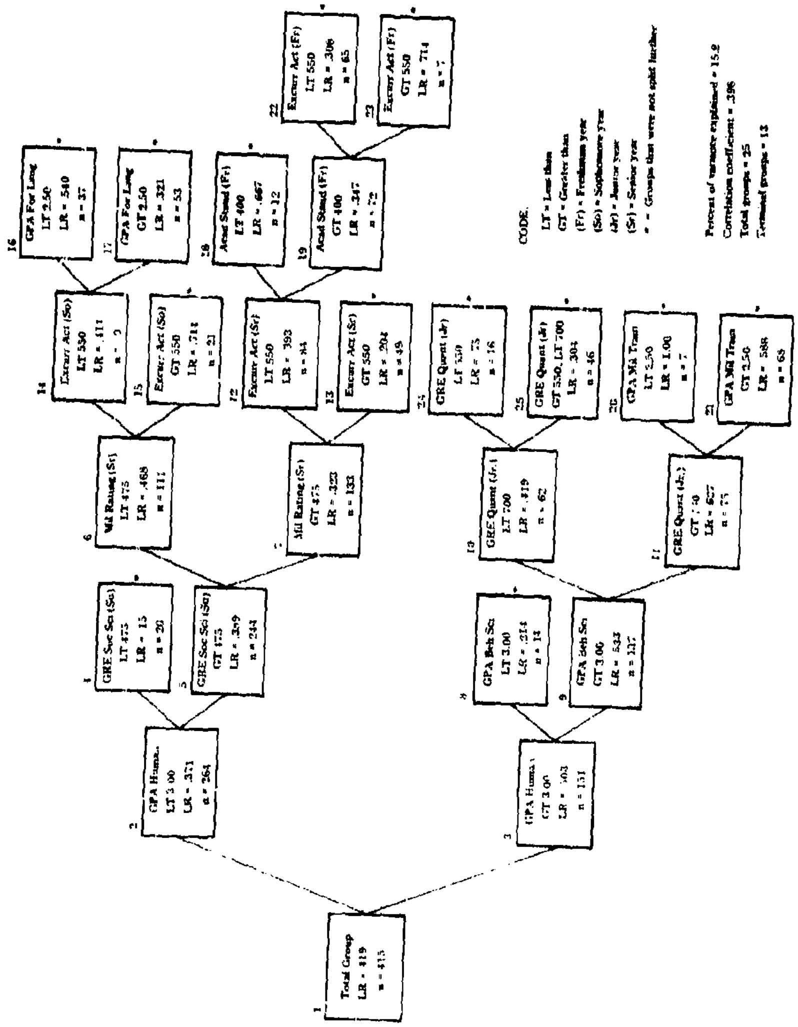

Fig. 2—Automatic Interaction Detector analysis of loss rates—class of 1965

groups. A split was not made if the maximum between-group sum of squares was less than 1 percent of the total sample's total sum of squares, if the group to be split had less than 30 observations, or if 25 groups had already been generated. In the analysis shown in Fig. 1, of all possible splits of all predictor variables, splitting the total group into those who had less than and those who had more than a 3.50 law GPA produced the maximum between-group sum of squares on the dependent variable, the loss rate. The number in each group and their average loss rate are shown in boxes 2 and 3 of Fig. 1.

Next, the subgroup with the largest total sum of squares was selected for possible further splitting—in this example, those whose law GPA was less than 3.50. Again a search was made across all possible splits of all predictor variables to find the split that maximizes the between-group sum of squares subject to the constraints noted above. The next split, in this case, divided those with less than a 3.50 law GPA into two groups, those having more and those having less than a 2.50 behavioral science GPA.

The process continued until no further splits were possible. When the splitting was completed, the total sample had been subdivided into 13 mutually exclusive terminal groups, where the best estimate for the loss rate of each group is given by the average loss rate for the terminal group. The defining characteristics for each terminal group are found by tracing backward from each terminal group to those groups from which it was previously split. For instance, group 8 with a loss rate of .629 is composed of all graduates who had less than a 2.50 engineering science GPA, greater than a 2.50 behavioral science GPA, less than a 3.50 foreign language GPA, and less than a 3.50 law GPA. If a subject did not fit all these criteria, he is not included in group 8.

Because the interactions beyond the third split are quite complicated, the interpretation of Figs. 1 and 2 is somewhat complex, but several general observations can be made. For both classes, the first two or three splits tend to be made on academic variables (GPAs or GRE scores), suggesting that for the total population such variables are better predictors of loss rates. Academic performance appears to have a differential effect on losses. Higher grades in law, behavioral science, and humanities tend to be related to higher loss rates, while higher grades in foreign language, engineering science, and chemistry tend to be related to lower loss rates. Those with higher GRE social science scores tend to have higher loss rates. However, the group in the class of 1964 with high humanities and behavioral science GPAs and high GRE quantitative scores has a high loss rate also.

Military performance also interacts in a complex way with the other variable. Where military performance variables (military rating, physical fitness score, military training GPA, conduct score, and extracurricular activities score) split another variable, there is a tendency for those with poorer military performance to have higher loss rates and those with better military performance to have lower loss rates. Exceptions occur in the class of 1965, where those with higher freshman and sophomore extracurricular activities scores tend to have higher loss rates.

The data in Figs. 1 and 2 indicate that those with higher grades in humanities and social science courses or lower military performance tend to have higher loss rates. Those with higher grades in science and engineering or higher military performance tend to have lower loss rates.

Prediction of Officer Effectiveness Ratings

The analyses of OERs for the two classes are shown in Figs. 3 and 4, using the same format as Figs. 1 and 2. Only officers who were still on active duty in September 1975 are included in these analyses. Each box in Figs. 3 and 4 shows the percentage of officers in that particular group who received all 9s in their last five effectiveness reports. All the variables in the AID composite analysis are shown in Table A.2 of the Appendix.

For both classes, those who received more 9 effectiveness ratings tended to have high military performance at the Academy as measured by peer ratings for the class of 1965 and junior military ratings for the class of 1964. For those in the class of 1964 who had low military ratings as juniors, participation in extracurricular activities as sophomores tended to be associated with low officer ratings, but participation in extracurricular activities as seniors tended to be associated with high officer ratings. For the class of 1965, those who had good peer ratings (less than 36) and high natural science GRE scores as sophomores tended to have better officer ratings if they also had high physical fitness scores as seniors. However, those who had poor peer ratings (greater than 36) tended to have better officer ratings if they also had a GRE humanities score in their senior year of less than 625 and a GPA in physical education courses lower than 2.50. This latter finding may be due to idiosyncratic splits of the data or it may mean that these particular individuals were effectively working in Air Force duties that required few interpersonal relations skills and little aptitude in the humanities and physical activities.

The manner in which academic performance, measured by GRE scores or GPAs, interacts with military performance is complicated. In the class of 1964, those with higher military ratings tended to have even higher effectiveness ratings if they had a freshman nonscience GPA above 2.00. In the class of 1965, those with good peer ratings had

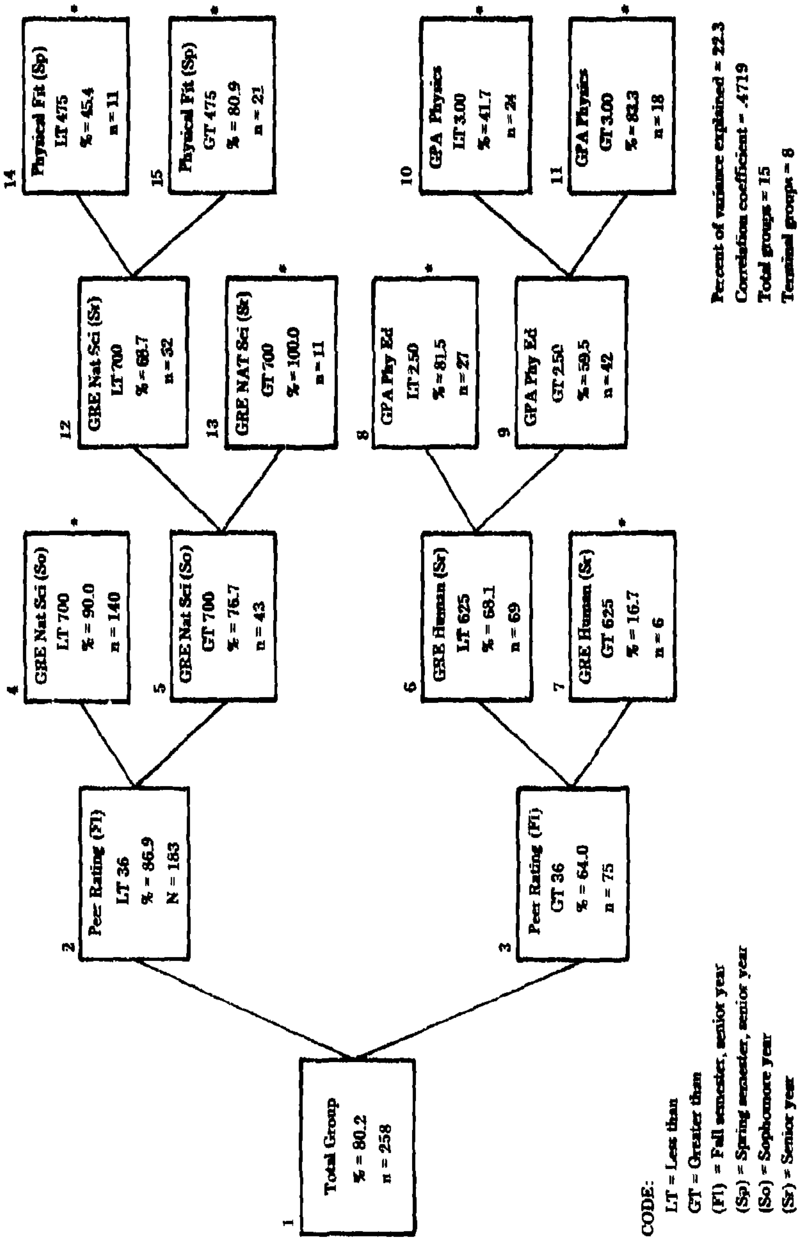

Fig. 3—Automatic Interaction Detector analysis of officer effectiveness ratings—class of 1965, percent receiving all 9s

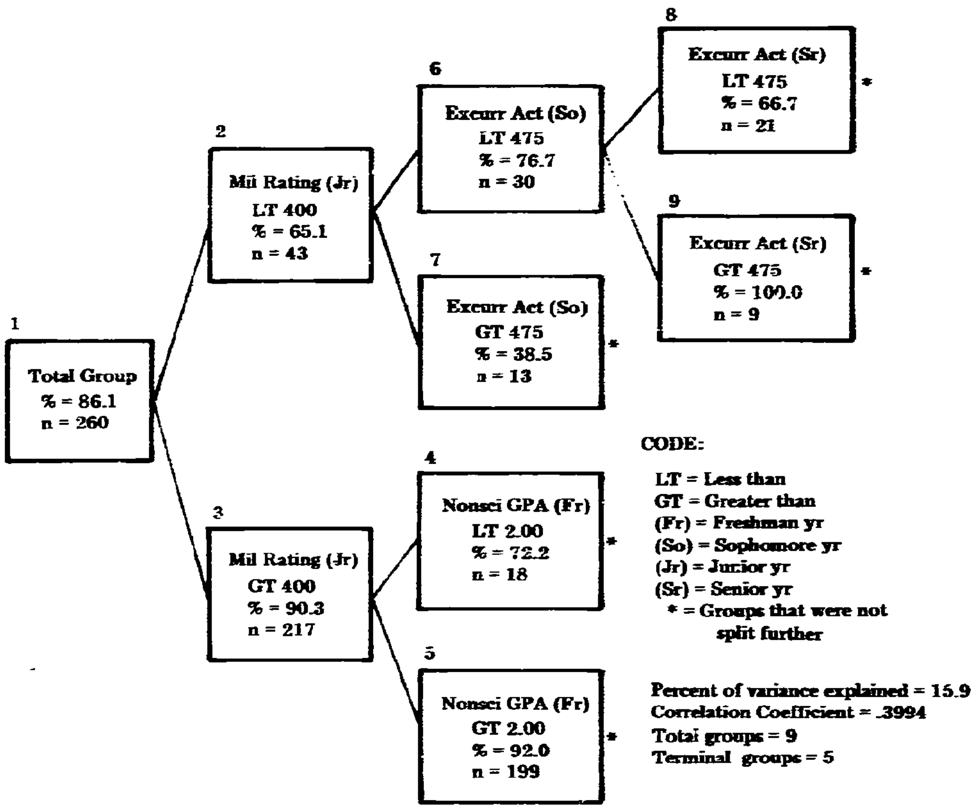

Fig. 4—Automatic Interaction Detector analysis of officer effectiveness ratings—class of 1964, percent receiving all 9s

even better effectiveness ratings if their sophomore GRE natural science score was less than 700. However, this relationship is reversed when the senior GRE natural science score is introduced. Those with good peer ratings and sophomore and senior GRE scores above 700 tended to have very good effectiveness ratings. Also, in the class of 1965, having a high physical education and physics GPA tended to offset the negative effects of low peer ratings.

In summary, Academy military performance appears to be more predictive of OERs than academic performance. Where academic variables did operate to split groups, there is no consistent indication that high academic performance is associated with higher effectiveness ratings.

Prediction of Early Promotion to Major

The analyses of early promotions for the two classes are shown in Figs. 5 and 6. Only officers who were still on active duty in September 1975 are included in these analyses. Each box in Figs. 5 and 6 shows the percentage of officers in that particular group who were promoted to major earlier than their contemporaries. All the variables in the AID composite analysis are shown in Table A.3 of the Appendix.

In the class of 1965, those performing in the top 10 percent as measured by senior year academic standing were four times more likely to be promoted earlier than the remainder of the class. Those with lower senior year academic standing improved their chance of early promotion if they had high peer ratings and if they had lower social science GRE scores in their senior year. If the latter scores were high, then chances for promotion improved if the person also had a high nonscience GPA in his junior year. Those with a lower academic standing in their senior year and low peer ratings tended to improve their chances for promotion if they had low humanities GRE scores in their senior year and a high military training GPA.

The patterns of interactions that emerged from the analysis of the class of 1964 did not closely match those of the class of 1965. The primary predictor for the class of 1964 was freshman military rating, with those having high ratings being three times more likely to be promoted early. Those with low freshman military ratings improved their chances for early promotion if they had high extracurricular activities scores as seniors. Those with high freshman military ratings tended to have lower chances for early promotion if they had an English GPA greater than 2.50, low junior and senior year military ratings, and a low athletic activities index in high school.

In summary, either high academic standing or good peer ratings were predictive of early promotion for the class of 1965. However, for

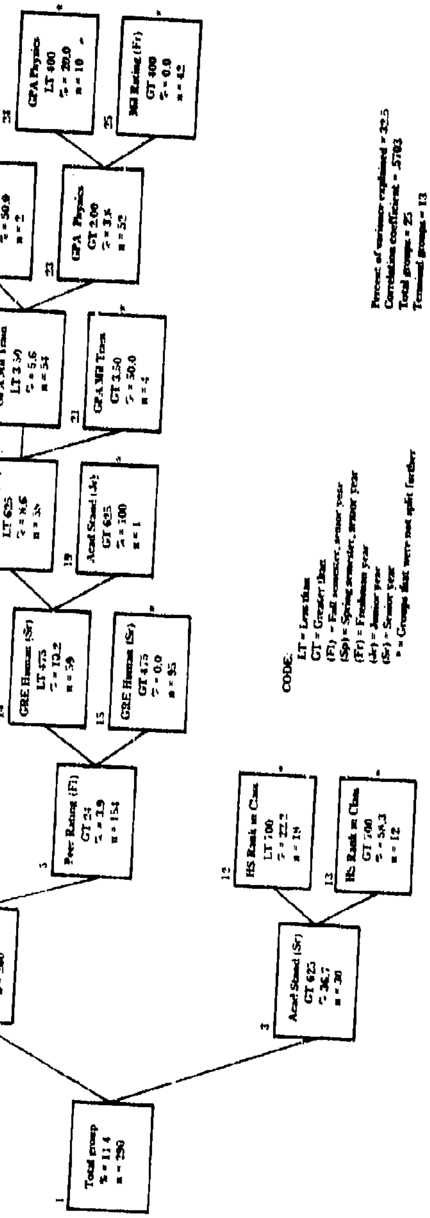

Fig. 5—Automatic Interaction Detector analysis of early promotions to Major—class of 1965, percent promoted

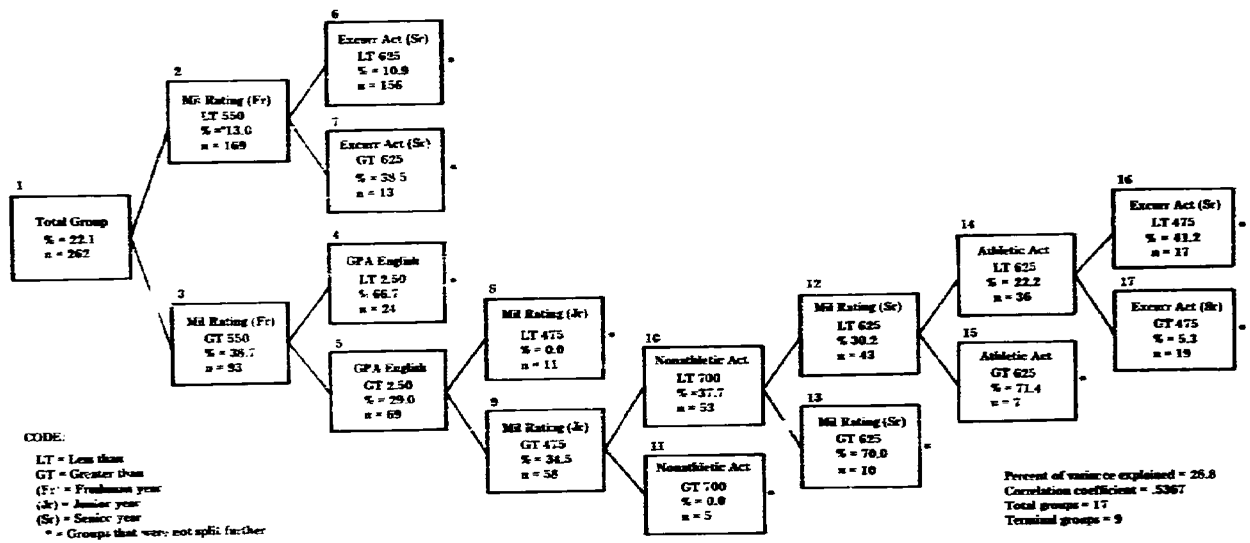

Fig. 6—Automatic Interaction Detector analysis of early promotions to Major—class of 1964, percent promoted

the class of 1964, early promotion was primarily related to good military performance. For this class, academic performance was not a key predictor of early promotion. The difference between the best predictors for the two classes may be the result of using somewhat different variables in the two analyses. Another factor may be that almost twice as many from the class of 1964 (72) were promoted early as from the class of 1965 (38).

CONCLUSIONS

There are no simple summary statements relating Academy cadet performance to subsequent officer retention and performance. Depending on the criterion used to measure active duty performance, the class analyzed, and the variables that are included as possible predictors, different conclusions and interpretations emerge.

The statistical procedure used in this study enhances the probability of uncovering interactive effects. Certainly, a number of complex interactions occur in this study. Because of the small sample sizes, some of these interactions may be due to sample instability and random variation in the data. The strong interactions that occur in both classes suggest that it may be difficult to assess which is the "best" predictor. The predictive power of a variable often depends on the levels of other variables. Cadets who perform at a low level in one area—say, military performance—may be able to compensate by higher performance in other areas—say, academics.

The analysis revealed that some measures of military and academic performance are probably better than others in predicting active duty behavior. Consistent with other research (Korman, 1968), cadet peer ratings are better predictors than officer ratings of cadet performance. Physics and foreign language GPAs appear to be better predictors than other GPAs, such as mechanics and economics, whereas in several analyses GRE scores were better predictors than GPA. However, it should be remembered that the AID picks the "best" variable for splitting a group to maximize the between-groups sum of squares. The variables not picked may be almost as good or fairly poor; the analysis presented here does not address how good the second and third best variables are.

While most performance rewarded at the Academy is positively related to retention and performance on active duty, the findings also suggest that not all "good" performance at the Academy is associated with "good" performance in the Air Force. There is a tendency for those who do well in humanities and social sciences to incur higher active duty loss rates. A similar pattern is seen in some of the OER and early promotion splits, though the tendency is not as dominant. However, there is some indication for the class of 1965 that doing well in academics as a whole enhances the opportunity for early promotion.

Variables reflecting high school performance and criteria used in the Academy selection process did not enter the prediction tree for active duty loss rates and OERs. High school athletic and nonathletic activities and the CEEB (College Entrance Examination Board) English Composition score played a minor role in the prediction of early promotions.

Clearly, data collected on cadets after they enter the Academy are more strongly related to their behavior in the Air Force than data collected before they enter the Academy. This may be true for several reasons. More variables measuring cadet performance were included in the data base. Many of these variables deal with behaviors and abilities that have direct relevance and application in Air Force jobs. Second, data collected on cadets at the Academy are subject to greater control, standardization, and refinement than high school data from a variety of sources. Academy data may be of higher quality and may more effectively discriminate between individuals than pre-Academy data. Last, being more recent, Academy data may more accurately reflect the degree of maturation, skill development, and cognitive learning the graduate possesses on active duty.

The analyses reported here do not completely explain graduates' retention and performance. Only between 15 and 32 percent of the total variation in the criterion variables is explained by the terminal groups generated by the AID. A complete model describing graduate performance and retention would include a number of factors not considered in this study. At a minimum, an expanded model should include training and work experience in the Air Force, leadership and management practices to which the graduate was exposed during active duty, alternative employment opportunities, and personality and socioeconomic background characteristics. Conceivably, all these factors could interact with Academy performance data. The relationship between cadet performance and officer performance, in fact, may be moderated by the training, duties, and management of the graduate on active duty.

This study has focused only on that subset of variables that are directly under the control of Air Force Academy policymakers. While the study provides additional insight, it does not suggest definitive conclusions and prescriptions for changing the Academy's training philosophy and procedures. The findings of this study are qualified and tentative. As noted earlier, although the AID is appropriate for identifying interactions and complicated relationships, for small sample sizes its results may be adversely affected by sampling instability.

Also, the Academy has changed a number of policies and procedures since the officers considered in this study graduated. Until more complete knowledge of the relationship between Academy performance and officer performance is developed, including an understanding of how post-Academy experiences affect the officer's performance, it is premature to suggest changes in Academy programs.

Appendix

VARIABLES INTRODUCED AS POSSIBLE PREDICTORS OF LOSS RATES, OERs, AND EARLY PROMOTIONS

Table A.1

VARIABLES INTRODUCED AS POSSIBLE PREDICTORS OF LOSS RATES, COMPOSITE ANALYSIS

Class of 1965	Class of 1964
High school total GPA	High school total GPA
High school rank in class	High school rank in class
GRE social science (sophomore yr)	GRE social science (sophomore yr)
GRE quantitative (junior yr)	GRE quantitative (junior yr)
GRE humanities (senior yr)	GRE humanities (senior yr)
Academic standing (freshman yr)	Academic standing (freshman yr)
Graduation order of merit	Extracurricular activities (freshman yr)[a]
Science GPA (freshman yr)	Military rating (freshman yr)[a]
Science GPA (4 yr cumulative)	Extracurricular activities (sophomore yr)[a]
GPA military training	Military rating (sophomore yr)[a]
GPA chemistry	Extracurricular activities (junior yr)[a]
GPA behavioral science	Military rating (junior yr)[a]
GPA foreign language	Extracurricular activities (senior yr)[a]
GPA law	Military rating (senior yr)[a]
GPA engineering science div	Graduation order of merit
GPA humanities div	Science GPA (freshman yr)
Extracurricular activities (senior yr—fall)	Science GPA (4 yr cumulative)
Conduct score (senior yr—fall)	GPA military training
Physical fitness test (senior yr—spring)	GPA chemistry
Conduct score (senior yr—spring)	GPA behavioral science
	GPA foreign language
	GPA law
	GPA engineering science div
	GPA humanities div

[a]These variables were added to the class of 1964 analysis to compensate for the fact that the last four variables in the class of 1965 list were not available for the class of 1964.

Table A.2

Variables Introduced as Possible Predictors of Officer Effectiveness Ratings, Composite Analysis

Class of 1965	Class of 1964
High school rank in class	High school rank in class
CEEB English composition	CEEB English composition
GRE social science (sophomore yr)	GRE social science (sophomore yr)
GRE natural science (sophomore yr)	GRE natural science (sophomore yr)
GRE adv. engineering (junior yr)	GRE adv. engineering (junior yr)
GRE humanities (senior yr)	GRE humanities (senior yr)
GRE natural science (senior yr)	GRE natural science (senior yr)
Military rating (freshman yr)	Extracurricular activities (freshman yr)[a]
Academic standing (senior yr)	Military rating (freshman yr)[a]
Nonscience GPA (freshman yr)	Extracurricular activities (sophomore yr)[a]
Total GPA (freshman yr)	Military rating (sophomore yr)[a]
Total GPA (sophomore yr)	Extracurricular activities (junior yr)[a]
Total GPA (senior yr)	Military rating (junior yr)[a]
GPA physical ed.	Academic standing (senior yr)
GPA chemistry	Extracurricular activities (senior yr)[a]
GPA physics	Military rating (senior yr)[a]
GPA English	Nonscience GPA (freshman yr)
Peer rating (senior yr—fall)	Total GPA (freshman yr)
Physical fitness test (senior yr—spring)	Total GPA (sophomore yr)
Conduct score (senior yr—spring)	Total GPA (senior yr)
Leadership composite (senior yr)	GPA physical ed.
	GPA chemistry
	GPA physics
	GPA English

[a]These variables were added to the class of 1964 analysis to compensate for the fact that the last four variables in the class of 1965 were not available for the class of 1964.

Table A.3

Variables Introduced as Possible Predictors of Early Promotions, Composite Analysis

Class of 1965	Class of 1964
High school rank in class	High school rank in class
CEEB English composition	CEEB English composition
CEEB math achievement	CEEB math achievement
High school athletic act. index	High school athletic act. index
High school nonathletic act. index	High school nonathletic act. index
GRE humanities (sophomore yr)	GRE humanities (sophomore yr)
GRE social sciences (senior yr)	GRE social sciences (senior yr)
GRE humanities (senior yr)	GRE humanities (senior yr)
Military rating (freshman yr)	Extracurricular activities (freshman yr)[a]
Academic standing (junior yr)	Military rating (freshman yr)
Academic standing (senior yr)	Extracurricular activities (sophomore yr)[a]
Graduation order of merit	Military rating (sophomore yr)[a]
Nonscience GPA (junior yr)	Academic standing (junior yr)
GPA military training	Extracurricular activities (junior yr)[a]
GPA aero	Military rating (junior yr)[a]
GPA physics	Academic standing (senior yr)
GPA English	Extracurricular activities (senior yr)[a]
Peer rating (senior yr—fall)	Military rating (senior yr)[a]
Conduct score (senior yr—fall)	Graduation order of merit
Peer rating (senior yr—spring)	Nonscience GPA (junior yr)
Officer rating (senior yr—spring)	GPA military training
	GPA aero
	GPA physics
	GPA English

[a]These variables were added to the class of 1964 analysis to compensate for the fact that the last four variables in the class of 1965 were not available for the class of 1964.

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A DYNAMIC MODEL FOR OPTIMAL BONUS MANAGEMENT

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The bonus provides an exceptionally powerful personnel management tool for the military services—and an exceptionally difficult management problem. Current criteria for awarding bonuses are rather crude and tend to be based on the deviation between the actual and the desired inventory by years of service. Attention is not explicitly paid to training costs, civilian substitutability, skill criticality, or other factors related to the military specialty. The "desired" inventory is based chiefly on achieving the minimum number of supervisory-grade personnel required.

A study of the bonus management problem, undertaken to suggest bonus policies and bonus criteria for promoting the efficient use of bonuses within the DoD is described. A dynamic model of optimum bonus awards based on the principle of optimal control of a military specialty, which operates over a medium-term planning horizon of 10 to 15 years and includes 20 YOS groups, is described. The objective function is to maximize the integral of the value of the production from that specialty less the costs of manning that specialty. The output gives the values of the bonus awards to that specialty over the planning horizon. One of the benefits of the model is the ability to determine the effects of the initial inventory levels in the specialty on bonus policy.

Results are expected in three different areas: (1) the development of bonus guidelines and criteria that will aid in the year-to-year management of the bonus program; (2) an understanding of the dynamics of manpower and personnel management, given an initial inventory, a target inventory, the costs of deviation from the target, and the bonus costs of adjusting the inventory; and (3) a method for integrating short-term management practices in the form of bonus, accession, and retention policies with long-term management objectives. These results, it is hoped, will extend beyond bonus management to areas such as grade management, which are also integral to long-term manpower and personnel management of military forces.

INTRODUCTION

This paper provides an economic approach to the problem of managing the military bonus program. The bonus program was designed to provide the Department of Defense (DoD) with a flexible form of compensation that could be used to stimulate enlistment and retention of enlisted personnel in particular specialties. The great advantage of bonuses is that they can be targeted at specific specialties or year groups within specialties that are experiencing shortages for variable lengths of time. Because bonuses can be applied selectively, they are potentially a much more cost-effective form of compensation than basic pay, which varies by grade and years of service but is uniform across specialties. If basic pay were the only policy tool available, rents would have to be paid in attractive specialties in order to eliminate shortages in unattractive specialties.

Administration of the bonus program has suffered from the lack of a framework for determining where bonuses should be paid. The manpower distributions generated by the services' objective force models are adopted as targets, and bonuses are considered where necessary to attain these targets. However, because of budget constraints, not all targets can be achieved and the practical problem is one of trading off between bonus costs and shortages. In determining bonus levels, consideration is given to such factors as shortages or surpluses in year groups other than the one immediately eligible for a bonus; the cost of training a new recruit relative to the cost of retraining a fully trained man; whether the specialty experiences persistent shortages in the career force or is merely understrength in particular cohorts; and the criticality of the specialty in the overall defense mission.

In practice, bonuses are used both to introduce permanent interspecialty pay differentials, necessitated by underlying differences in supply and demand, and to reduce temporary or cohort-specific shortages resulting from past or present fluctuations in supply or demand. The criteria currently applied reflect this dual role of bonuses. But the several criteria are not integrated into a single framework that yields a single optimal set of bonuses for a given specialty after weighing both steady-state and short-run considerations.

The purpose of this paper is to provide such a framework. Bonus management is formulated as an economic problem with the tradeoffs that have been made implicitly being made explicit. The solution is separated conceptually into two phases. In the first phase, the optimal normal or steady-state set of bonus levels for a particular specialty is determined simultaneously with the optimal or target manpower distribution. First-term training cost is a prime determinant of optimal retention, hence of the optimal steady-state reenlistment bonus. In the second phase, the optimal temporary deviations from the normal bonus set are determined, given the initial inventory and the constraint that the target inventory be attained within a fixed number of periods. The steady-state model developed by Jaquette and Nelson (1974) can be used for the first phase. This paper presents a dynamic adjustment model of the second phase. The larger question of allocating a fixed bonus budget among specialties is not addressed.

Overall specialty strength is measured by a production function, which is essentially a weighted aggregation function of men in different years of service. This function formally structures the notion that the importance of a shortage in one year group depends on manning levels in other year groups and on substitutability between them. Deviations of specialty strength around the target level are evaluated using a domand function. The elasticity of demand is chosen to reflect the criticality of the specialty, which depends on the availability of men with similar skills in other specialties. The interval supply structure of a military specialty, in which the stock of future senior men is determined by the rate of retention of current junior men, is embodied in the supply function.

Because the optimal bonus for any year group depends on present strength within that and other year groups and on the effect of current policy on future strengths, optimal bonus levels for all eligible year groups at all points in the time horizon are determined simultaneously. The optimal structure of bonuses over time is defined as that which maximizes net benefits, subject to the constraint that the arbitrarily chosen starting manpower inventory reach the desired inventory within the number of periods assigned. Maximization of net benefits is shown to be equivalent to minimizing the sum of the two sources of cost—the bonus cost incurred to reduce shortages and the penalty cost associated with deviating from target strength.

The solution methodology and some illustrative results of the computer simulation model are presented. The total cost of following the optimal bonus policy derived from the model is compared with the cost of strict year-group management, i.e., paying the bonus necessary to achieve target strength in each year group in each year, and with a policy of paying no bonuses but simply setting the accession rate at the steady-state level and waiting for these optimal size cohorts to flow through the system. With two alternative sets of parameter values, the cost of year-group management exceeds the cost of the optimal policy by between 30 and 70 percent and both policies show large savings over a no-bonus policy.

In its present form, the computer simulation model accommodates eight year groups and two bonuses, an enlistment and a reenlistment bonus. It could, in principle, be expanded to handle a more realistic representation of a military specialty, and modifications necessary to include training as an alternative policy tool to bonuses are described in the Appendix. In its present form, it illustrates the viability of this framework for managing bonuses. It demonstrates that a flexible policy, which takes into account conditions of substitutability, supply, and criticality, achieves substantial savings compared with a rigid policy of year-group management.

INSTITUTIONAL BACKGROUND

Bonuses are one of the major forms of incentive pay for enlisted personnel. They are intended to be used to bring manpower up to desired levels in specialties experiencing shortages. Under current authorization,[1] bonuses can be awarded at three levels in a specialty to stimulate accessions and retention: (1) an enlistment bonus, payable on completion of training, of up to $3,500; (2) a selective reenlistment bonus (SRB Zone A), at first reenlistment, between two and six years of service, of up to $12,000;[2] and, (3) a second selective reenlistment bonus (SRB Zone B), at six to ten years of service, of up to $10,000.

The bonus program gives the DoD an important means of introducing flexibility into the rigid basic compensation structure. In contrast to basic pay, which admits variation by grade and years of service (YOS) but is uniform across specialties and can be revised only by an Act of Congress, bonus levels vary across specialties and are adjusted biannually. In the absence of bonuses, rigidity of the pay structure results in shortages and surpluses in different specialties, because supply and demand conditions vary across specialties at any one time and may vary over time within any one specialty. If basic pay were the only policy tool available, substantial rents would have to be paid in attractive specialties in order to eliminate shortages in unattractive specialties. The flexibility of bonuses thus makes them a relatively efficient form of compensation.

The bonus program has confronted the services with the need to justify their bonus requests and the DoD with the need to define consistent criteria by which to evaluate these requests. The services base their requests on their existing objective force (steady-state) and projection models, heavily supplemented by judgment.[3] The Army,

[1] P.L. 93-277.

[2] $15,000 maximum for nuclear-trained personnel.

[3] The description of service practices draws on a report on meetings with representatives of the services on December 19 and 20, 1974, to obtain information on procedures used in awarding bonuses (Nelson and Enns).

Navy, and Air Force have objective force models that generate desired distributions of men by YOS.[4] Manpower projection models are then used to predict shortages or surpluses relative to desired manning levels. Bonus requests are based on the predicted shortages. The Navy looks at shortages over zones of two YOS groups (5 to 7 YOS for SRB Zone A, 8 to 10 YOS for SRB Zone B). One-step adjustments upward or downward from steady-state bonus levels are made for deviations of greater than 10 percent from desired levels. The Air Force focuses on projected shortages in the single year group affected by the bonus and "will normally consider paying a bonus if there is an anticipated shortage of more than 10 percent."[5] Overall manning in the specialty and training costs relative to bonus costs are also considered.[6] The Army as yet has no systematic formula to derive bonus requests from projected shortages. The Marine Corps has no formal objective force or projection models but considers training costs, manning levels, and past bonus levels to determine requests.

As guidelines for evaluating service requests, a recent DoD instruction on the subject lists the following characteristics as qualifying a specialty for SRB Zone A:[7]

1. Serious undermanning in a substantial number of adjacent career years (three or more) which can be affected by the bonus.
2. Chronic and persistent shortages in total career manning.
3. High first-term replacement costs, including training costs.
4. Relative unattractiveness of the skill compared to other military skills or civilian alternatives.
5. Necessity of the skill for the accomplishment of defense missions.

The instruction further states that "even if the foregoing criteria are not completely satisfied, the SRB level will not be reduced by more than two increments in a given fiscal year." The precise level of bonuses to be awarded are based on a "balanced evaluation" of these criteria.[8]

The proliferation of criteria for awarding bonuses and the difficulty in reconciling them in practice reflect the fact that bonuses are

[4] The Navy's ADSTAP system of models also solves for steady-state bonus award levels by rating. These models are discussed in detail in Jaquette, Nelson, and Smith (1977).

[5] OASD (M&RA) Staff Recommendations (1974), p. 2.

[6] Ibid.

[7] DoD Instruction 1304.22 (1975).

[8] Ibid.

being used to attain two conceptually distinct goals of specialty management:

1. *To obtain the desired steady-state distribution of manpower by YOS.* In this context, bonuses would be a permanent feature of the pay system in some specialties. Such differentials may be necessary, because supply conditions vary even if desired retention rates (demand) are uniform across specialties. For example, in the absence of second-term pay differentials, actual retention will be negatively related to first-term training content if military training has value in the civilian sector. The effects of supply-induced persistent shortages in highly trained specialties will be magnified if, as dictated by cost-effectiveness considerations, desired retention rates are positively related to first-term training.[9]
2. *To eliminate temporary shortages.* The existing manpower inventory reflects policies of the previous thirty years and may thus be very different from the desired distribution in all YOS groups. Actual manning levels may, therefore, suggest paying bonuses either larger or smaller than steady-state levels. For example, even if the projected number of first-term reenlistments is equal to the desired number with a low-level SRB, it may be optimal to pay a higher-level bonus and temporarily overshoot if there is a shortage in more senior year groups or, conversely, to pay no bonus and undershoot if there is a surplus of senior careerists.

In addition to these considerations of long- and short-run manning levels, a third consideration, at least in the DoD criteria, is efficient budget allocation. Given a projected shortage, either temporary or permanent, the cost of paying a bonus is to be weighed against its effectiveness in reducing the shortage, and against the cost effectiveness of such alternatives as retraining.

The common feature underlying the criteria used by the services and the DoD in determining bonus policy is deviation of actual from desired strength, in various YOS groups. In addition, the DoD considers the cost effectiveness of the bonus relative to alternative policies. Either implicitly or explicitly, most of the considerations that arise if bonus management is viewed as a strictly economic problem are taken into account in these criteria. What is lacking is a systematic way of reconciling conflicts between the indications of the several criteria and determining precise bonus levels. This task has been relegated to

[9] The use of bonuses for steady-state objectives is likely to become more prevalent with the phasing out of Shortage Specialty Proficiency Pay. To the extent that they are viewed by enlistees as uncertain, being reviewed biannually, bonuses are an inefficient form of permanent compensation, since expected bonus payments will be discounted by the recipient, assuming risk aversion.

judgment. When decisions are based on judgment, consistency across specialties, within and between services, is difficult to achieve and even more difficult to prove.

The approach taken in this paper is to formulate the bonus management problem as an economic problem, integrating the several relevant considerations into a single framework and explicitly stating the tradeoffs that must be made, and have been made implicitly, by decisionmakers. Judgment is not eliminated but is structured as the explicit selection of the values of the parameters of the model.

ECONOMIC FORMULATION OF THE BONUS MANAGEMENT PROBLEM

Assuming that bonuses will continue to be used to manage both persistent (steady-state) and temporary shortages, the optimal bonus policy for a particular specialty over time may be determined in two stages:

1. The optimal steady-state level of bonuses may be derived from a static optimization model. In the static model, the problem is to find the cost-minimizing distribution of men by YOS and the corresponding structure of steady-state wages necessary to attain the desired manning levels, subject to a constraint on the overall strength of the specialty.[10] The model developed by Jaquette and Nelson (1974) is a prototype of this sort. Once optimal steady-state wages are determined, optimal steady-state bonuses are the difference between optimal and constrained actual wages. Note that the usefulness of the concept of steady-state bonuses does not require the force to attain a steady state, which it obviously never does. A steady-state bonus is simply the bonus that will normally have to be paid if supply and demand conditions are expected to remain stable for several years and basic pay is fixed.
2. The optimal temporary or transition-phase structure of bonuses may then be determined from the dynamic adjustment model, which also yields the optimal path of manpower from the starting inventory to the steady state. This is the model discussed here. Bonuses in this model are to be interpreted as deviations, positive or negative, from steady-state wages. To avoid confusion, the term "wage" will be used to refer to steady-state wages, which may in practice include a bonus

[10] If steady-state wages are considered not variable for some year groups, for example, those beyond eligibility for Zone B SRB, the model can be estimated subject to this constraint.

component. The term "bonus" will refer to deviations from steady-state wages. Thus, in the adjustment model, when no bonus is being paid, it is understood that the level of compensation is equal to the steady-state wage.

In both models, optimization entails setting wages or bonuses such that for each year group, the marginal cost of an additional man is equal to his marginal product or contribution to output. In the steady-state model, marginal cost is determined by steady-state supply conditions, with supply at each YOS depending on expected earnings over the entire future career. Marginal product, measured net of training costs, is evaluated at the constrained steady-state level of output.

In the adjustment model, marginal cost is determined by the bonus cost necessary to induce reenlistments at other than the steady-state rate. Marginal product is measured in terms of the reduction in the penalty assigned to deviating from the target level of output in each year of the transition period. Because the cost of adjustment to the desired inventory increases with the speed of adjustment, it is typically not optimal to attempt to attain the target inventory immediately.[11] For example, a shortage in the junior career force may be reduced by increasing the accession rate to the specialty, which would be less expensive than using a reenlistment bonus to raise retention from existing smaller cohorts. However, the former policy will not eliminate the shortage for several years. The optimal bonus policy requires weighing the cost, in terms of bonus payments, against the benefits of eliminating the shortage more rapidly. The cost depends on the elasticity of the short-run supply function in response to a bonus. The benefits depend on shortages and surpluses in other year groups within the same specialty, and substitution possibilities between them and the year groups with shortages; on the criticality (for the overall defense mission) of a shortage in this specialty; and on the implications of current manning for future shortages or surpluses, given the limited ability to add or discharge men at more senior YOS levels. Thus, optimization over the transition from the current to the target inventory requires simultaneous determination of bonus policy for all three bonuses at each point of the transition period.

[11] Viewed as a problem of finding the optimal adjustment path between current and long-run equilibrium inventories, bonus management is closely analogous to the problem of disequilibrium factor demand addressed by Eisner and Strotz (1963), Lucas (1967), and Nadiri and Rosen (1973). The model is complicated in the military context by the internal labor supply characteristics of a military specialty and the absence of a market price of output at which to evaluate the costs of deviations from desired output levels.

A DYNAMIC OPTIMIZATION MODEL OF BONUS MANAGEMENT

Overview of the Model

Given an initial inventory of men by YOS and a target inventory to be attained within a specified time period, the models solves for the pattern of bonuses over time that maximizes net benefits over the period. Net benefits are defined as the difference between the (social) value of output and its (social) cost. The quantity of output is calculated using a production function that aggregates men in the different productivity categories into an overall measure of specialty strength. In the simplest form of the model, productivity categories correspond to YOS groupings. To convert output to dollar units for comparison with costs, output is evaluated according to a demand function. The value per unit of output at the target or equilibrium value of output is set equal to marginal cost.[18] The value per unit of output at other levels of output is then determined using a constant-elasticity demand function. The elasticity-of-demand parameter is chosen to reflect the criticality of the specialty, which depends on its role in the defense mission and the availability of substitutes from other military specialties or from the civilian sector.

Cost is measured by wages plus bonuses minus inframarginal rents. On the assumption that military compensation is equal to the supply price of the marginal recruit, and that this is equal to his potential civilian wage, which measures his social value in the civilian sector, this measure of costs corresponds to social opportunity cost. The supply functions of men in year groups eligible for a bonus incorporate steady-state reenlistment rates plus a linear response to the bonus. For a year group not amenable to control by a bonus, the supply function simply reflects steady-state continuation from the previous year group.

The objective function to be maximized is the sum of net benefits over the transition period. Bonuses are chosen to maximize this function, subject to attaining the desired inventory at the terminal time, T. The objective function reduces to a quadratic loss function in deviations of actual from desired input levels, with the penalties assigned to deviations from target being derived from the parameters of the demand, production, and supply functions. Thus considerations currently used in an ad hoc manner by bonus managers—criticality of specialty, substitution possibilities between year groups in the special-

[18] Marginal cost is equal to the value of the Lagrange multiplier obtained by solving the steady-state problem of finding the cost-minimizing input mix, subject to an output constraint.

ty, and the effectiveness of a bonus in reducing a shortage—are systematically related in the model. Outputs of the model include optimal bonuses, distribution of men by years of service, penalty costs, and bonus costs in each year. In addition, the solution methodology generates the shadow value of men in each year group, which indicates where other control policies, such as cross-training or early separations, might be used to reduce total costs.

The following sections discuss the components of the model—the production function, the demand function, the supply function, and the overall objective function—for the simplest case, in which bonuses are the only policy tool. Modifications necessary to take account of alternative policy options such as accelerated within-specialty training and cross-training are discussed in Munch (1977). The solution methodology and illustrative results of the computer simulation model are presented and compared with the costs of a strict year-group management policy and a no-bound policy.

Production Function

In the absence of a measurable output, potential output must be measured as some function of the total number of men. Simple aggregation is inappropriate because individuals differ in productivity through factors such as innate ability, formal training, and experience. Therefore, the service models disaggregate men by YOS or skill level and derive individual target-strength levels for each of these "input categories." The problem with using this type of model to measure overall specialty strength is that men within a category are implicitly assumed to be homogeneous, hence perfect substitutes, whereas substitutability between categories is zero. The former assumption may be tenable if the categories are sufficiently disaggregated to distinguish the main determinants of productivity. The latter assumption, of zero substitutability between categories, is obviously unrealistic.[13] An aggregation function, with weights reflecting relative productivity of men in different categories and the substitution possibilities among them, is needed to relate overall military effectiveness to the number of men in each productivity category. The production function is such a weighted aggregation function.

The production function used is a nested constant elasticity of substitution (CES) function of the general form:[14]

[13] The problem arises partly because many of the models are designed to describe personnel flows and promotion opportunities, where substitutability is not an issue.

[14] Sato (1967).

$$Z = [\sum_{i=1}^{n} \delta_i X_i^{-\rho}]^{-\frac{\mu}{\rho}},$$

and

$$X_i = \left[\Sigma_{j \varepsilon i} \delta_j^{(i)} L_j^{(i)-\rho_i}\right]^{-(1/\rho_i)},$$

$$\sum_{i=1}^{n} \delta_i = \sum_{j \varepsilon i} \delta_j^{(i)} = 1,$$

$$-1 < \rho_i = \frac{1-\sigma_i}{\sigma_i} < \infty, \qquad i = 1, \ldots, n,$$

$$-1 < \rho = \frac{1-\sigma}{\sigma} < \infty,$$

where Z = specialty output,
X_i = i^{th} composite input,
L_j^i = j^{th} basic input in i^{th} composite,
δ = distribution parameter,
ρ = substitution parameter,
μ = returns to scale parameter, and
σ = elasticity of substitution.

Overall specialty output, Z, is a CES function in [X], and X_i, in turn, is a CES function in $[L^i]$. Hence, Z is a two-tier CES function in the basic input [L]. The intragroup elasticity of substitution within the i^{th} tier or composite input is denoted by σ_i. Intragroup elasticities may differ across the X_i. The intergroup elasticity of substitution among the composite inputs, denoted σ, is constant. The advantage of this multi-tier formulation is that it permits variation in the elasticity of substitution between pairs of basic inputs.[18] To illustrate the application of this production function to a military specialty, [L] may denote the set of basic inputs within which individuals are perfect substitutes, such as YOS, and [X] may denote terms of service. Thus,

[18] σ_i, the direct partial elasticity of substitution between basic inputs in the i^{th} composite, is given by

$$\sigma_i = -\frac{\partial \log (L_j/L_k)}{\partial \log (MP_j/MP_k)}, \quad j, k \in x_i.$$

L_2^1 denotes number of men in the second year of the first term, and X_1 denotes number of quality adjusted man-years in the first term. The two-tier formulation permits a specification that, say, men in different year groups in the third terms are better substitutes for each other than men in different year groups in the first term, and men in different terms are poorer substitutes than men in different year groups within the same term. If substitution within each term is perfect, $\rho_i = 1$ and the function collapses to a single-tier function in men distinguished solely by term of service. Alternatively, [X] may denote skill levels or grades, if these are considered better measures of productivity than term of service.

The δ are distribution parameters. They reflect the relative productivity of the different inputs. For example, if $\delta_2 = \delta_3$ then the marginal productivity of second- and third-termers is equal at the point where the number of second- and third-termers is equal. μ is the returns-to-scale parameter. Returns to scale are diminishing, constant, or increasing as $\mu \lesseqgtr 1$. The basic model assumes $\mu < 1$, since the effectiveness of a specialty depends on inputs other than manning levels; in particular, it depends on capital in this specialty and manpower and capital in other specialties.[16] If these complementary factors are regarded as fixed for the purposes of planning bonuses in a particular specialty, returns to labor alone in that specialty will be diminishing.

The simplest formulation groups men by YOS for the basic input categories, [L], and by terms of service for the composite inputs categories, [X].[17] This implies that experience on the job is the sole determinant of productivity. Individual productivity may vary across individuals within a year group, but the average is constant and independent of the number of individuals in the year group, their premilitary training, their training in the military, and their consequent skill and grade distributions. Possible modifications of the model to reflect the more realistic but more complex determinants of productivity are discussed in Munch (1977), together with the appropriate modifications of the supply and objective functions.

Selection of the parameters of the production function is largely a matter of judgment rather than empirical evidence. The techniques used to estimate substitution parameters of private sector production functions from either time series or cross-sectional response to

[16] Suppressing other optimal inputs from the production function in a model to determine the optimal distribution of men by YOS presupposes that the relative productivity of different labor categories is independent of the availability of capital.

[17] Measuring inputs as stocks rather than flows of services ignores the possibility of varying output from a given stock by varying rates of utilization. In the absence of overtime pay, this may be less feasible in the military than in the civilian sector.

changes in relative factor prices are inappropriate for the military. In addition to the problem that technology and other factor inputs cannot be assumed constant across specialties or time periods, the basic assumption underlying the procedure, that the input mix is designed to minimize costs, is untenable for the military, at least without allowing for lags of unknown length. The parameters are therefore estimated subjectively, and the model is programmed to facilitate sensitivity analysis of the outcome with respect to all input parameters.

Supply Function

The supply function relates the units of the production function to the control variables. In the simple model, with inputs defined as YOS groups unadjusted for quality, the supply function for the i^{th} element of the vector of basic inputs is of the form:

$$L_{i,t} = \alpha_{i-1} L_{i-1,t-1} + \beta_i B_{i,t} + K_i, \qquad (1)$$

where $L_{i,t}$ = number of men in the i^{th} YOS in the specialty in year t,
α_{i-1} = continuation rate from YOS_{i-1} at steady-state wage levels (zero bonus),
$B_{i,t}$ = bonus for reenlistment into YOS_i in year t, and
K_i = steady-state lateral entry flow into YOS_i. For $i \neq 1$, K_i may be zero.

The assumption underlying this short-run supply function is that reenlistments into YOS_i in the year t are affected only by bonus payments for which they are currently eligible, $B_{i,t}$. This contrasts with the supply specification of the steady-state model, in which the reenlistment decision is based on expected earnings over the entire military career, not just the immediate term of service.[18] The dichotomy is appropriate because, by definition, steady-state wages correspond to long-run average pay and hence provide a rational basis for calculating expected career earnings. Bonuses, interpreted strictly as transitory deviations from steady-state pay, will be perceived to vary from year to year. It would be irrational to base expectations of future bonuses at more senior YOS on current bonuses at those YOS. Given this uncertainty as to future bonuses, transitory deviations from steady-state supply to a particular term of service are likely to be

[18] See Jaquette and Nelson (1974).

dominated by current bonus payments for that term, as specified in Eq. (1).[19]

In the discrete formulation of the supply function, all reenlistments occur at the beginning of an accounting period, in response to the bonus set in that period. The term of commitment is the same for everyone in a particular YOS[20] and is constant over the time horizon. The possibility of using variation in term of commitment across individuals or early-out programs in conjunction with bonus policies, solving endogenously for the optimal term of service, possibly with variation over the time horizon, is precluded.[21] The estimated costs of an optimal bonus policy under this constraint will be an upper bound on costs if bonuses are used in conjunction with flexibility in term of commitment. Reenlistments occur only at the end of a term of service, in response to the current bonus level. Early reenlistments and extensions are not permitted.[22]

The parameters of the supply function, α_i and β_i, are assumed to be independent of the size of the cohort eligible for reenlistment. This is defensible only in terms of computational simplicity. If civilian opportunities or tastes for the military are positively correlated across individuals at all points in the career, then it is likely that marginal continuation rates will be less than average continuation rates; that is, the average continuation rate, α, will be inversely related to the size of the eligible cohort. Conversely, the absolute response to a given level of bonus award, β_i, is likely to be positively related to the size of the eligible cohort. Thus, the correct specification presumably lies somewhere between a constant proportionate response $[L_{it}/L_{i-1,t-1} = a_i + \beta_i B_{i,t}]$ and a constant absolute response $[L_{i,t} = \alpha_i + \beta_i B_{i,t}]$. The specification used here incorporates biases in offsetting directions, with an overestimate of the continuation rate and an underestimate of the bonus effect in the case of an abnormally large cohort, and conversely in the case of a below-average size cohort.[23]

[19] The specification assumes that bonuses are paid in a lump sum at the reenlistment point. The current method of payment in installments over the term can, in principle, be modeled, but it adds complexity because of the dichotomy introduced between cost to DoD and value to the recipient. This problem is handled in the steady-state context in the Jaquette-Nelson model. Ignoring it is less serious in the case of a bonus payment, extending typically only over a four-year term, than it would be for an entire career earnings stream.

[20] The five terms of service may be of different lengths.

[21] A comparison of the costs of different lengths of commitment can be made only by running the model under alternative specifications and comparing costs.

[22] In practice, the possibility of early reenlistments and extensions makes the supply response at any one time a function of current bonus levels, relative to past and expected future bonus levels.

[23] The notion that the (absolute and relative) response to a bonus is inversely related to the no-bonus reenlistment rate, which is embodied in the DoD improvement factor tables, may be incorporated by varying β_i inversely with α_i in running the model for different specialties.

A further implication of the supply specification adopted is that supply to a particular year group derives primarily from continuations or reenlistments from the previous year group within the same specialty. Within a term, the previous year group is the exclusive source of supply. However, the response to the bonus is not constrained in the simple model. This formulation may be modified to correspond to varying degrees of lateral entry. For example, constraints could be imposed on the model to represent the case where the previous year group within the specialty or a feeder specialty is the exclusive pool of potential reenlistments. At the other extreme, if lateral entry is unrestricted and no more costly than drawing from within the specialty, and firing within a term is costless,[24] this can be modeled by omitting the reenlistment term and specifying a positive steady-state flow of lateral entrants:

$$L_{i,t} = K_i + \beta_i B_{i,t}.$$

Demand Function

The role of the demand function is to assign a dollar value to deviations from the target level of output to weigh the benefits of moving closer to target against the costs in the form of bonus payments. The demand function states the value placed on an additional unit of specialty output. This marginal value, or price, is postulated to vary inversely with the absolute level of specialty output. The functional form used has the property of constant elasticity:

$$P = \alpha\, Z^{-(1/\epsilon)},$$

where P = price of specialty output,
α = a scale parameter, and
ϵ = elasticity of quantity with respect to price.[25]

The elasticity parameter, ϵ, is a crude measure of the criticality of the specialty. It depends on manning levels and supply elasticities in related specialties, both substitutes and complements. For example,

[24] Introducing the possibility of early-out programs would require modification of the supply functions of both the steady-state and adjustment models. Risk-averse individuals will attach a positive value (hence, accept lower per-period wages) to a commitment of guaranteed employment for a fixed term from the employer, but attach a negative value (hence, require higher wages) to committing themselves to serve for a fixed term. Thus, the net effect of a mutual obligation to a fixed term of service is uncertain a priori and may vary with the length of the term. However, if the obligation is relaxed on the employer's side only, as implied by making early-out programs a policy variable, the supply curve would shift to the left.

[25] The discussion is in terms of ϵ, the elasticity of quantity with respect to price, to conform to the conventional definition of the elasticity of demand.

for a combat arms specialty that is crucial to the defense mission and has no close substitutes, the elasticity of demand will be low. A given percentage deviation of actual from desired manning levels induces a more than proportionate response in the marginal value per unit of output. Conversely, a specialty with readily available substitutes is likely to have a high elasticity of demand, other things being equal. In principle, the range of possible substitutes extends over different specialties within one service, as well as across services and to civilians. The demand elasticity is likely to be lower if the model is applied to a career manning field (CMF), rather than specialty by specialty within a CMF.

The constant elasticity assumption implies an equiproportionate response of price to shortages and surpluses. This is appropriate if substitution possibilities between specialties are symmetric. In other words, if the availability of substitutes to perform the functions of specialty A, in the case of a shortage in A, is highly correlated with the availability of alternative and equally valuable cases of men trained in A, in the case of a surplus in A, the constant elasticity assumption is reasonable for small deviations around the steady-state level of output.[26]

The value of the parameter α is found by equating price to marginal cost at the steady-state level of output and solving the demand equation for α.[27]

Objective Function and Solution Methodology

The objective is to maximize the sum of net benefits—i.e., benefits minus costs—over the transition period. Benefits and costs are defined in terms of social rather than private values.[28] Thus if the DoD is viewed as a producer of defense output, it is assumed to maximize social welfare rather than "private" profit. These differ because both demand and supply functions are assumed to be less than perfectly elastic.[29] Maximization of private net benefits, in the absence of price

[26] The demand function is not used to determine the steady-state level of output. This is discussed in the appendix to this paper.

[27]

$$P_0(Z_0) = \alpha Z_0^{-(1/\epsilon)} = \lambda(Z_0),$$

where λ = marginal cost. Marginal cost is given by the value of the Lagrange multiplier obtained by solving the steady-state model for the input mix that minimizes cost, subject to producing the output level Z_0.

[28] This is the formulation commonly used in the public utility literature. It assumes that the DoD demand curve reflects the value placed by society on defense output and that the supply price of labor to the DoD reflects its civilian opportunity cost.

[29] If perfect price discrimination is exercised in both product and factor markets, social and private benefits and costs converge. Thus, the formulation of the model can

discrimination, would imply exploitation of monopsony and monopoly power by the DoD in purchasing labor services and "selling" output to the public, yielding wage rates less than the value of marginal product of labor and levels of output at which marginal social value exceeds marginal social cost.

An implication of maximizing social rather than private net benefits is that the model generates an optimal labor force mix that does not minimize DoD budget cost for a given level of output.[30] This results from treating inframarginal rents as a transfer payment, not as a cost of production. Therefore, the optimal factor mix contains more of the factors in relatively inelastic supply than would the factor mix that minimizes budget cost. In any case, maximization of social rather than private benefits is a particular specification, not a necessary feature of the model. The private benefits-maximizing formulation is given in Munch (1977).

Social benefit (SB) is measured as total "revenue" (price times quantity) plus consumer's surplus:

$$SB = \sum_{t=1}^{T} \left[\int_0^{Z_t} P_t(Z_t(L_t))\, dZ_t \right],$$

where P(Z) = demand function for specialty output,
L = n – dimensional vector of labor inputs, and
T = terminal time of planning horizon.

Social cost (C) is measured as total budget cost less inframarginal rent, or social opportunity cost:

$$C = \sum_{t=1}^{T} \sum_{i=1}^{n} \left[\int_0^{L_{i,t}} S_i(L_{i,t})\, dL_{i,t} \right],$$

where $S_i(L_i)$ = supply function of i^{th} labor category. The objective function is therefore

$$SB - C.$$

Taking a second-order Taylor expansion and eliminating terms, the objective function reduces to

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be interpreted as maximizing private benefits with perfect price discrimination. Bonus awards in practice are multiples of individual base pay, which differs by grade, so it is not uniform across individuals in the same YOS group. To the extent that this variation in military pay is positively correlated with variation in supply price across individuals, there is some degree of price discrimination in practice.

[30] With perfect price discrimination, social cost minimization coincides with DoD budget minimization.

$$\frac{1}{2} \sum_{t=1}^{T} \overline{L}_t' F \overline{L}_t - B_t' U B_t ,$$

where $\overline{L}_t$ = vector of deviations of actual from steady-state input levels,
B_t = vector of bonuses,
F = matrix of second partial derivatives of benefits function, and
U = matrix of second partial derivatives of inverted supply function.

The objective function is simply a quadratic loss function in the deviations of actual from steady-state input and wage levels, $\overline{L}_t$ and B_t. The penalties assigned to these deviations, the matrices F and U, are derived from the parameters of the demand, production, and supply functions.[31]

The problem is to choose the time paths of the control variables, the three bonuses, that maximize the objective function, subject to the constraints of the supply conditions and of attaining the target vector by the terminal period. Applying Pontryagin's maximum principle, define the Hamiltonian function, H, by adjoining the supply function, S(L,B), to the objective function with the vector multiplier function, λ':

$$H_t = \frac{1}{2} [\overline{L}_t' F \overline{L}_t - B_t' U B_t] + \lambda_{t+1}' [S(L_t, B_t)] .$$

Here, λ is a vector of costate variables that are the dynamic equivalents of the Lagrange multipliers of static problems involving maximization subject to constraints. Each costate variable may be interpreted as the shadow price of the associated state variable.

First-order necessary conditions for a maximum are

$$\frac{\partial H_t}{\partial B_{it}} = 0, \qquad (2)$$

[31] These matrices are derived as follows:

$$F_{ii} = \frac{\partial^2 SB}{\partial L_i^2} = \frac{\partial P}{\partial Z} \left(\frac{\partial Z}{\partial L_i}\right)^2 + P \frac{\partial^2 Z}{\partial L_i^2} ,$$

and

$$U_{ii} = \frac{\partial^2 C}{\partial L_i^2} = \frac{\partial W_i}{\partial L_i} = \frac{1}{\beta_i} .$$

$$L_{i,t} = \alpha_{i-1} L_{i-1,t} + \beta_i B_{i,t} + K_i \,. \tag{3}$$

$$\lambda_{i,t} = \frac{\partial H}{\partial L_{it}} \,. \tag{4}$$

In Eq. (2), the control variables are chosen to maximize the objective function, subject to the supply constraints of Eq. (3). In Eq. (4), the shadow price of each input is equated to its marginal contribution to the objective function.

The first-order conditions indicate the nature of the solution. Expanding Eq. (2) for the first component:

$$\frac{\partial H}{\partial B_i} = \beta_1^2 F_{11} B_1 + \beta_1 \sum_{i=2}^{n} F_{1i} \overline{L}_i - \beta_1 B_{1t} + \alpha_1 \beta_1 \lambda_{2t+1} = 0 \,.$$

$$\hat{B}_{1t} = (1 - \beta_1 F_{11})^{-1} \left[\sum_{i=2}^{n} F_{1i} \overline{L}_{it} + \alpha_1 \lambda_{2t+1} \right] . \tag{2.1}$$

$\hat{B}_{1t}$, the optimal enlistment bonus in year t, is determined by the contribution of an L_1 to output in year t, as measured by the summation of the own and cross partial derivatives of the gross benefits function, weighted by the manning levels in each labor category, plus the shadow value of an L_2 in year t + 1, $\lambda_{2,t+1}$, weighted by the probability of continuing from the first to the second YOS, α_1.

From Eq. (4),

$$\lambda_{2,t} = \frac{\partial H}{\partial L_{2t}} = \sum_{i=1}^{n} F_{2i} \overline{L}_{it} + \alpha_3 \lambda_{3t+1} \,.$$

$\lambda_{2,t}$, the shadow value of an L_2 at time t, is equal to its contribution to output in year t plus its expected shadow value as an L_3 in year t+1, which in turn incorporates productivity as an L_3 plus expected shadow value the next period, and so on. Thus, the expected value of the i^{th} input throughout its future career is reflected in its shadow price at time t. This in turn affects the optimal bonus paid to that input category at time t.

The effect on the optimal bonus of substitution possibilities between input categories and of shortages and surpluses is also evident from these first-order conditions. Since $F_{11} < 0$, the denominator in Eq. (2.1) is positive, the effect on $\hat{B}_{1t}$ of a shortage in the i^{th} input category ($\overline{L}_{i,t} < 0$) is positive if L_i and L_1 are substitutes ($F_{1i} < 0$), negative if they are complements ($F_{1i} > 0$). Conversely, a surplus of substitutes decreases B_{1t}. Similarly, the effect of future shortages and surpluses is embodied in the λ_{2t+1} term. If all inputs are at target levels, all shadow prices and bonuses are equal to zero.

The first-order conditions yield a set of 2n − 2 difference equations in the n input categories and their corresponding costate variables,[32] and m equations for the m control variables. Particular solutions are defined by the boundary conditions on the state variables, with L(0) corresponding to the initial inventory and L(T) to the target inventory.

Results

Tables 1 through 5 present results obtained from the computer simulation model.

In this simplified version of the model there are eight basic input categories, corresponding to men in YOS 1 through YOS 8, and two composite input categories, corresponding to the first and second term. An enlistment bonus can be paid to YOS 1 and a reenlistment bonus to YOS 5. The elasticity of substitution between men in different year groups within the same term is infinite ($\sigma_1 = \sigma_2 = \infty$). The elasticity of substitution between men in different terms is high in Case I (σ = 10), low in Case II (σ = .25). Continuation rates (α) between year groups are .95 within the first term, 1.0 within the second term. The no-bonus reenlistment rate from the first to the second term is .72. The supply elasticity of both first- and second-termers in response to a bonus is 2.0. The demand elasticity is high (2.0) in Case I, low (.15) in Case II.

Tables 1 and 3 show the manpower inventories for the two cases under the optimal bonus policy derived from the model and under a year-group management policy in which bonuses are set to achieve the target inventories in YOS 1 and YOS 5 in each year, regardless of manning levels in other year groups. The model is constrained to reach the target inventory in the ninth year. The starting inventory is given by the first row, except that L_1 and L_5 are determined endogenously by bonus policy. In the absence of a bonus, L_1 would be equal to the steady-state reenlistment rate (323), and L_5 would be 160, by assumption. Thus, the initial condition is one of shortage in all year groups except L_2, which is in equilibrium, and L_8, which has a surplus.

Tables 2 and 4 present the bonus levels and bonus, penalty, and total costs for each year under the alternative policies. In addition, the

[32] Equations for L_1 and λ_1 are excluded because the supply equation for L_1 can simply be incorporated into the objective function, dispensing with the need for adding this supply equation as a constraint. This simplification cannot be adopted for the other input categories whose supply includes continuation from previous year groups.

Table 1

CASE I: MANPOWER INVENTORIES

	Optimal Bonus Policy								Year-Group Management							
Year	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
1	356	307	200	200	206	170	180	220	323	307	200	200	200	170	180	220
2	335	339	292	190	183	206	170	180	325	307	292	190	200	200	170	180
3	330	318	322	277	163	183	206	170	323	307	292	278	200	200	200	170
4	325	313	302	306	207	163	183	206	323	307	292	278	200	200	200	200
5	324	309	298	287	218	207	163	183	323	307	292	278	200	200	200	200
6	324	308	293	282	200	218	207	163	323	307	292	278	200	200	200	200
7	324	308	292	278	200	200	218	207	323	307	292	278	200	200	200	200
8	323	307	293	279	200	200	200	218	323	307	292	278	200	200	200	200
9	323	307	292	278	200	200	200	200	323	307	292	278	200	200	200	200

<u>Case I Parameter Values</u>

$\delta_1 = .25$	$\alpha_5 = \alpha_6 = \alpha_7 = 1.0$
$\delta_2 = .75$	$\varepsilon = 2$
$\sigma = 10$	$s_1 = 2$ = supply elasticity to first term
$\sigma_1 = \infty$	$s_2 = 2$ = supply elasticity to second term
$\sigma_2 = \infty$	$\beta_1 = .032$
$\alpha_1 = \alpha_2 = \alpha_3 = .95$	$\beta_2 = .01$
$\alpha_4 = .72$	$\alpha_4 L_4(0) = 160$

Table 2

CASE I: COSTS
(In dollars)

	Optimal Bonus Policy					No-Bonus Policy		Year-Group Management				
Year	Enlistment Bonus	Reenlistment Bonus	Bonus Cost	Penalty Cost	Total Cost	Penalty Cost	Year	Enlistment Bonus	Reenlistment Bonus	Bonus Cost	Penalty Cost	Total Cost
1	1,040	4,569	121,700	46,856	168,556	125,109	1	0	4,000	80,000	76,185	156,185
2	376	3,911	78,738	53,882	132,621	265,666	2	0	5,600	156,800	35,658	192,458
3	212	2,650	35,828	46,939	82,767	343,023	3	0	6,300	198,450	9,129	207,579
4	54	773	3,031	10,602	13,633	242,857	4	0	0	0	0	0
5	31	-200	216	6,227	6,443	109,838	5	0	0	0	0	0
6	39	-682	2,350	998	3,348	24,028	6	0	0	0	0	0
7	17	-358	645	6,714	7,360	1,969	7	0	0	0	0	0
8	5	-46	11	3,345	3,357	1,941	8	0	0	0	0	0
9	0	0	0	0	0	84	9	0	0	0	0	0
Total			242,520	175,564	418,084	1,114,520				435,250	120,972	556,222

Table 3

Case II: Manpower Inventories

Year	Optimal Bonus Policy L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8	Year-Group Management L_1	L_2	L_3	L_4	L_5	L_6	L_7	L_8
1	356	307	200	200	228	170	180	220	323	307	200	200	200	170	180	220
2	327	338	292	190	251	228	170	180	323	307	292	190	200	200	170	180
3	319	310	321	277	184	207	228	170	323	307	292	278	200	200	200	170
4	321	303	295	305	193	184	207	228	323	307	292	278	200	200	200	200
5	324	305	288	280	212	193	184	207	323	307	292	278	200	200	200	200
6	324	308	290	273	200	212	193	184	323	307	292	278	200	200	200	200
7	324	308	292	275	200	200	212	193	323	307	292	278	200	200	200	200
8	323	307	293	278	200	200	200	212	323	307	292	278	200	200	200	200
9	323	307	292	278	200	200	200	200	323	307	292	278	200	200	200	200

Case II Parameter Values

$\delta_1 = .25$

$\delta_2 = .75$

$\sigma = .25$

$\sigma_1 = \infty$

$\sigma_2 = \infty$

$\alpha_1 = \alpha_2 = \alpha_3 = .95$

$\alpha_4 = .72$

$\alpha_5 = \alpha_6 = \alpha_7 = 1.0$

$\epsilon = .15$

$s_1 = 2$ = supply elasticity to first term

$s_2 = 2$ = supply elasticity to second term

$\beta_1 = .032$

$\beta_2 = .01$

$c_4 L_4(0) = 160$

Table 4

CASE II: COSTS
(In dollars)

Year	Optimal Bonus Policy: Enlistment Bonus	Reenlistment Bonus	Bonus Cost	Penalty Cost	Total Cost	No-Bonus Policy: Penalty Cost	Year	Year Group Management: Enlistment Bonus	Reenlistment Bonus	Bonus Cost	Penalty Cost	Total Cost
1	1,036	6,769	246,309	93,976	340,285	966,058	1	0	4,000	80,000	388,372	468,372
2	116	6,316	199,682	56,877	256,558	3,533,300	2	0	5,600	156,800	474,559	631,359
3	-127	4,665	109,094	23,401	132,495	5,756,350	3	0	6,300	198,450	145,476	343,924
4	-61	-640	2,109	25,908	28,018	4,099,620	4	0	0	0	0	0
5	30	-757	2,878	2,725	5,603	1,737,970	5	0	0	0	0	0
6	39	-168	165	20,648	20,814	377,119	6	0	0	0	0	0
7	17	313	494	4,657	5,150	33,020	7	0	0	0	0	0
8	49	182	166	24,532	24,699	32,571	8	0	0	0	0	0
9	0	0	0	0	0	1,004	9	0	0	0	0	0
Total			560,897	252,724	813,621	16,537,000				435,250	1,008,405	1,443,655

Table 5

SUMMARY OF COSTS
(In dollars)

	Case I			Case II		
Category	Bonus Cost	Penalty Cost	Total Cost	Bonus Cost	Penalty Cost	Total Cost
Optimal bonus (1)	242,520	175,564	418,084	560,897	252,724	813,621
Year-group management (2)	435,250	120,972	556,222	435,250	1,008,405	1,443,655
No bonus (3)	0	1,114,520	1,114,520	0	16,537,000	16,537,000
Net gain or loss (2) - (1)	192,730	-54,592	138,138	-125,647	755,681	630,034
Net gain or loss (3) - (1)	-242,520	938,956	696,436	-560,897	16,284,276	15,723,379

penalty cost that would be incurred if no bonuses were paid is calculated to provide an alternative benchmark against which to measure the gains from following an optimal bonus policy. Comparing the optimum with year-group management, the main conclusion to be drawn is that, because of its inflexibility, year-group management results in paying excessive bonuses in Case I, where substitutability is high and the specialty is not critical ($\epsilon = 2$), and insufficient bonuses in Case II, where low substitutability and inelastic demand make it optimal to overshoot the year-group targets initially to compensate for shortages in other year groups. These conclusions are summarized in Table 5. In Case I, the optimal policy generates savings on bonus costs that more than offset the higher penalty costs, to give a net gain of $138,138 over year-group management. In other words, year-group management results in total costs that are roughly 33 percent higher than those under the optimal policy. Conversely, in Case II, the optimal policy incurs higher bonus costs in order to reduce penalty costs. The total excess costs of year-group management are $630,034, or 77 percent higher than those of the optimal policy. But both policies show huge savings over a no-bonus policy.

CONCLUSION

The criteria currently used by the DoD in managing the bonus program reflect steady-state and short-run considerations, since, given the rigidity of the basic pay structure, bonuses are the only policy tool available to introduce either permanent or temporary pay differentials across specialties to counter uneven conditions of shortage and surplus. This paper shows how the multiple factors that must be considered in managing bonuses efficiently can be integrated into a unified framework.

The problem is simplified by distinguishing two phases. Optimal steady-state bonuses are determined by permanent features of the specialty such as training costs, attractiveness of job content, etc. Optimal temporary deviations from the steady state are determined by differences between the actual and the desired steady-state inventory. Since the cost of bringing the actual inventory up to desired strength depends on the speed of this adjustment, the optimal policy over the transition phase requires weighing the bonus costs of eliminating a shortage against the penalty costs of tolerating the shortage temporarily. Bonus costs depend on the predicted no-bonus shortage and the elasticity of supply in response to a bonus. Penalty costs depend on the availability of substitutes for the year groups in shortage, both from within the particular specialty and in other specialties. These considerations can be quantified by appropriate selection of the parameters of the model.

The usefulness of this approach is illustrated by the computer simulation model. The optimal policy derived from the model achieves substantial savings, relative to a policy of strict year-group management. Year-group management pays the bonus necessary to attain target strength in each year group, without regard to conditions of oversupply or undersupply in other year groups or specialties and substitution possibilities between them. The optimal policy pays lower bonuses than year-group management when the specialty is not crucial, and concentrates the bonus effort on year groups that can be increased at relatively low cost. These bonus savings more than offset the higher penalty costs associated with the larger shortage. Conversely, in the case of a highly critical specialty, with shortages in senior year groups that cannot be affected by bonus policy, year-group management tends to pay inadequate bonuses and thus to incur high penalties and higher total costs than the optimal policy.

Appendix

RELATION BETWEEN STEADY-STATE AND ADJUSTMENT MODELS

In principle, given the parameters of the demand function, the long-run supply function and short-run adjustment costs, and the production function, a single model may be specified that solves simultaneously for the long-run equilibrium values of the input, output, and wage variables and the optimal adjustment path to that point from the initial point. This is the approach adopted in the economic literature (Eisner and Strotz, 1963; Lucas, 1967; Nadiri and Rosen, 1973). Simultaneous solution of the steady-state and adjustment problem is less appropriate for the military analyst. Because of the problems of measuring and evaluating output, it is not desirable to make the steady-state level of output depend on a necessarily arbitrary demand function. The steady-state problem is better formulated as one of cost minimization subject to an output constraint, where the constrained level of output is that obtained by applying the production function to the service target input levels. Such a model yields optimal input and wage levels, and the Lagrange multiplier gives the marginal cost per unit of output at the equilibrium level. The equilibrium input and wage values are the target values in the adjustment model, and the Lagrange multiplier is the equilibrium price. The arbitrary demand function is then used only for evaluating small deviations of output around this equilibrium level. It seems reasonable to treat the level of output (and budget) as unconstrained for the small range of options relevant to the adjustment between current and target inventory, making net benefit maximization an appropriate specification for this problem.[**]

A full steady-state optimum is derived from a model that treats all inputs and wage levels as variable, subject only to the constraints of the supply function. The Jaquette-Nelson model is of this type and may be modified to generate the steady-state data required by the dynamic adjustment model presented here.

In the absence of an operational steady-state model, the first-order conditions of such a model may be used to generate a reasonable set of data. The services' desired inventory is assumed to be optimal, and one wage level, W_j, is taken as given and assumed equal to the value of the marginal product. Then the optimal steady-state wages for the other labor categories can be determined from the first-order conditions (assuming perfectly elastic supply):

$$\frac{W_i}{W_j} = \frac{\delta_i}{\delta_j}\left(\frac{L_j}{L_i}\right)^{1+\rho} .$$

[**] In practice, the sum of optimal unconstrained bonuses for all specialties may exceed the allowed budget. The problem of optimal allocation of a fixed bonus budget among competing specialties is not addressed.

Obviously, steady-state wage parameters generated by this short cut are purely illustrative and not necessarily feasible or optimal. The equilibrium output price, λ, is obtained from the assumption that W_j is equal to the value of the marginal product:

$$W_j = \lambda \delta_j \left(\frac{Q}{L_j}\right)^{1+\rho} .$$

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Part IV

MANPOWER AND SOCIAL POLICY

ENLISTED WOMEN IN THE MILITARY[1]

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The increased utilization of women by the military has created unique problems in procurement, training, and management. Some of these problems are engendered by the basic incompatibilities between the traditionally masculine services and the values of American women; others arise when military men are required to interface with women as supervisors, peers, and subordinates.

Prior to the 1970s, the number of active-duty women never exceeded 2 percent of the total military force. Therefore, the services are not prepared to deal with either the 100 percent increase in womanpower achieved in 1975 or the impact that the passage of the Equal Rights Amendment portends for the future.

The experiences of foreign services and certain civilian communities (e.g., oceanographic research) are examined for policy considerations concerning the integration of women. In addition, case histories of military commands are developed to investigate how organizational and personal conflicts are resolved when women are introduced into a previously all-male environment.

INTRODUCTION

Being male has historically been a prerequisite for certain occupations in our culture. In big business, politics, religion, higher education, law, medicine, and the military, men work together and make

[1] EDITOR'S NOTE: It is important to recognize that many of the specific policies and practices discussed herein have undergone reexamination (and some have been or are likely to be changed) since this paper was first written. Nevertheless, this paper offers valuable insights into the historical use of women in the military, and most of the basic issues and principles are still valid.

critical decisions in a female-free environment. Only recently have changes in social attitudes and civil rights legislation forced a reexamination of the barriers that have kept most women out of the "action." The military services, however, have regulations and the sanction of federal law to maintain restrictions that prevent the assignment of women to some job specialties and greatly limit their numbers and duties in others. Army Regulation 600-200 excludes women from billets that are combat-oriented; Sections 6015 and 8549 of Title 10 of the United States Code, which apply to the Navy, Marine Corps, and Air Force, prohibit the assignment of women to aircraft having a combat mission and to duty on Navy vessels other than hospital ships or transports. These rulings have been interpreted in such a way as to prevent the assignment of women to billets that might be deployed in a military emergency. In the Navy, for example, this means that a woman may not be assigned for duty to a naval vessel for even a 24-hour period and may not participate in certain ship's operations.

The policies of the American military services are not very different from those of other nations. Nearly every country currently excludes women from combat-related billets, although some provide them with combat training. These policies have evolved despite demonstrations of courage and effectiveness on the part of military women during periods of national crisis or in insurgent movements when they fought side by side with men. There appears to be a historical protection of women that permeates diverse cultures and has obvious survival value.

MILITARY POLICIES AND THEIR EFFECTS

Women in the Israeli Defense Force

Modern Israel has some unique policies concerning military women that have promoted an image of equal treatment of the sexes. This is a misconception. Although Israel practices universal conscription of 18-year-olds, men and women have very different experiences after completing their basic military training.

Women in the Israeli Defense Force (IDF) belong to a separate corps called the CHEN, an acronym that in translation means charm. Young women are drafted for only 20 months, while men must serve for 3 years, but women remain in the reserve until their mid-40s. Their military experience is looked upon as a phase of young adulthood and is not incompatible with traditional femininity. This philosophy leads to the following practices, which are unlike those of the American military (Dickerson, 1974):

1. Women are overtly treated differently from men and no effort is made to make them fit a masculine mold. For example, CHEN women may go home to their families every night rather than live in military quarters, if they wish to do so.
2. Women rarely receive advanced training in a military specialty. Because the period of conscription for women is only 20 months, it is felt that funds for extensive training are better spent on men.
3. Women are not encouraged to remain in the IDF because there is a constant supply of new conscripts. Thus, the military is not looked upon as a career field for women, and little attention is given to their opportunities for advancement.
4. Women serve solely to release men for combat and, to date, there has been no movement within CHEN to achieve equality of opportunity with men in the IDF.

However, Israeli women can be assigned to any ground unit as noncombatants and, unlike American military women, they follow their units into combat, often coming under gunfire. They also may fulfill their military duty in teaching units or in the Nahal, the fighting pioneer youth who establish border settlements in hostile territory.

Status of American Military Women

The history of American women in the military begins in 1901, when the Army Nurse Corps was formed to care for the wounded of the Spanish-American War. Before World War II, the only use of women in nonnursing roles occurred briefly in 1918-1919 when the Yeoman (F) rating was created to free more men for sea duty (Butler, 1967). Yeoman (F) women worked as clerks, stenographers, typists, and telephone operators and represented the first time in our history that women were admitted to full military status. During an era when women were not permitted to vote, this was quite an accomplishment.

The women's services of today first came into being in May 1942, when the WAAC (Women Army Auxiliary Corps) was formed (Corson, 1942). Congresswoman Edith Rogers, who sponsored the bill creating the WAAC, attempted to gain full military status for Army women but was forced to compromise on an auxiliary corps. Two months later, however, the WAVES (Women Accepted for Voluntary Emergency Service) was created. This time, by law, women were designated as serving *in* rather than *with* the Navy. This was an important distinction in status and probably came about because of the mobilization pressures caused by Japanese successes during the early years of World War II. In the spring of 1943, the extra "A" was dropped from the title of the WAC, and Army women achieved military status separate from, but not equal to, that of men. This move was motivated by the findings of a study that a million and a half women could be effectively used in the Army but probably could not be recruited under auxiliary status. Two other wartime women's services, the Marine Corps Women's Reserve and the SPAR (from Semper Paratus, Always Ready) of the Coast Guard, also were formed in the early years of World War II.

Military women, like their civilian sisters, were used in a wide variety of jobs during World War II. Almost half of the enlisted WAC were assigned to administrative and office work, but others worked as bombsight maintenance specialists and Link trainer instructors. They were deployed overseas and were found in every major Army command. WAVES did not receive authorization to serve outside of the continental United States until September 1944. During the war years, over 55 percent of the uniformed Navy in Washington, D.C., was female (Corson, 1972). In addition, WAVES worked in all of the nonflying ratings of naval aviation. Table 1 shows the populations of the four women's services at the peak of mobilization in 1945. Creation of these groups was a wartime measure and was intended to be short-lived. However, in 1948, President Truman signed the Women's Armed Services Integration Act (P.L. 625) authorizing women in the regular Army, Navy, Air Force, and Marine Corps. Public Law 625 gave legal sanction to inequities between the sexes, including the following:

1. No person shall be enlisted who has not attained the age of 18 years; and further, no person under the age of 21 years shall be enlisted in such corps without the written consent of *her* parents or guardians.
2. The number of enlisted women shall not exceed 2 percent of enlisted strength and women officers shall not exceed 10 percent of enlisted female strength.
3. Women officers may not have a permanent commissioned grade above Commander (Navy) or Lieutenant Colonel (Army, Air Force, or Marine Corps).
4. Children of military women shall not be considered dependents unless their father is dead or their mother is their chief support.

Despite the demonstrated usefulness of military women, their representation in the services has remained low. In 1945, females in uniform represented only 2.18 percent of the armed forces. Five years later, in the 1950s, the percentage of women was down to 1.5 percent (Corson, 1972). It wasn't until 1967 (P.L. 90-130), during the Vietnam war buildup, that Congress removed the 2 percent limit on military women that had been set in 1948. Now the Secretary of each service

Table 1

NUMBER OF MILITARY WOMEN DURING PEAK MOBILIZATION IN 1945[a]

Service	Officer	Enlisted	Total
WAC	5,746	93,542	99,288
WAVES	7,055	78,945	86,000
Women Marines	831	17,578	18,409
SPAR	918	8,912	9,830
Total	14,550	198,977	213,527

[a]These figures exclude women officers in the healing arts.

determines the maximum number of women in his force. Women in the Marine Corps, for example, were limited to 1 percent of the enlisted force until 1973, when this quota was lifted. Today there are about 3,100 women in the corps, representing 1.6 percent of USMC personnel. The Navy has established a ceiling of 20,000 women, excluding officers. This goal represents 4 percent of the enlisted strength. The Air Force has 32,000 enlisted women. Their quota is 15 percent of their forces, rather than an absolute ceiling. General Jeanne Holm, former Director of the WAF, stated in 1972 that women, under present law, could make up 70 percent of the enlisted strength of the Air Force (Corson, 1972). The Army now has 45,000 women, representing 6 percent of their total forces. Thus, while the absolute number of women in uniform is about half that in 1945, their proportion has doubled. In spite of this, they still make up a much smaller minority group than blacks. To longtime military men, both officer and enlisted, women are far more of an enigma than are ethnic or racial minorities. To some, they are anathema.

Since 1970, the status of women in the military has greatly changed. For the most part, this change has been brought about by social and political forces acting upon the services. The progress of women has had its ups and downs, however, because of the inertia of the system and the reluctance of many of its members to transform what is often looked upon as the last bastion of male supremacy. Some changes have been painfully slow, eventually coming to pass only after court rulings upon discrimination suits brought by military women, as with the abolishment of pregnancy as grounds for mandatory discharge. Occasionally, by fiat, sweeping changes have occurred, as in August of 1972 when Adm. Elmo Zumwalt promulgated Z-Gram 116, which

1. Authorized limited entry of women into all Navy enlisted ratings.
2. Established a pilot program aboard USS SANCTUARY (AH-17) for evaluating use of women at sea and immediately assigned a limited number of female officers and enlisted personnel to the crew.
3. Suspended restrictions on women succeeding to command ashore.
4. Opened the Chaplain and Civil Engineer Corps to women officers.
5. Opened college NROTC programs to women and expanded the opportunities of women line officers.
6. Permitted women to achieve flag rank within the managerial and technical spectrum.

The actual changes in the status of Navy women that have occurred in the 3½ years since Z-Gram 116 highlight the disappointing disparity sometimes found between policy and practice:

1. USS SANCTUARY received its first complement of women in November 1972 and was decommissioned in March 1975. Although this pilot program was deemed successful (Commanding Officer, USS SANCTUARY), in that women generally performed at a high level and committed fewer disciplinary offenses than their male cohorts, the women-at-sea program ended and there are no plans to reinstate it at this time.
2. A total of nine women have succeeded to command ashore, and five are currently serving as COs.
3. There are now six female chaplains and four female civil engineer officers.
4. About 65 women are now attending college under the Navy ROTC scholarship program. The Secretary of the Navy recently approved a goal of 55 ROTC scholarships reserved for women each year.
5. There are no women flag officers except in the Nurse Corps, as before Z-Gram 116. However, two women are currently being considered by the Admiral Selection Board. (One was selected after this paper was written.)
6. Enlisted women never gained access to certain ratings, even to a limited degree. Currently, all enlisted ratings are classified into three categories, representing closed, controlled, and open jobs for women. Table 2 shows that the 15 ratings closed to women, the majority of which are performed only aboard ships, represent only 6 percent of all Navy rated billets. The last category, the open ratings, is somewhat mis-

named, since quotas are applied here, too. For example, in FY 1975, there were only two openings for women into the Gunner's Mate rating. The table also points out the maldistribution of women, in that almost 80 percent are confined to jobs that represent 56 percent of the rated billets.

Table 2

RATING CONTROL OF NAVY WOMEN[a]

	N	Percentage of Rated Billets	Percentage of Rated Women
Closed	15	6.0	0.0
Controlled	44	38.3	20.8
Open	43	55.7	79.2
Total	102	100.0	100.0

[a]Based on 1975 requirements for 294,715 rated personnel.

As the opportunities for women opened, new patterns of use began to emerge in the services. Table 3 shows the shift observed in the WAC between December 1973 and December 1974 (Savell, Woelfel, and Collins, 1975). A traditional Army Military Occupational Specialty (MOS) was defined in the analysis as a job to which at least 3 percent of the WAC not in basic training were assigned. These data show that the proportion of women in traditional MOSs dropped 9 percentage points in one year. The majority (3.7 percent) of women have gone into law enforcement. Of the Army's 451 MOSs, 415 are now open to enlisted women. Army personnel have expressed disappointment, however, in what is seen as women's lack of interest in pursuing some of these opportunities. Military women respond that many of these newly integrated jobs are unappealing and are generally filled by male enlistees who fail to qualify for technical training.

The Navy, which has determined that no more than 20,000 women can be used without disturbing sea and shore rotations for men, gives a different picture. Table 4 presents data that parallel the Army statistics except that they are based on the fiscal year. The 1973 data reflect the status of women before Z-Gram 116 (August 1972), which opened so many opportunities for women. By June 1974, only nine months later, there appears to be a shift of almost 6 percentage points away from the traditional ratings. However, by March of 1975, a reversal has occurred. This finding is probably due to the 35 percent increase in rated women and the limited number of permanent shore-based

Table 3

PERCENTAGE OF ARMY ENLISTED WOMEN IN TRADITIONAL CAREER FIELDS

Career Field	1973 (N = 11,173)	1974 (N = 17,085)
Medical	31	25
Administration	35	33
Communication	11	9
Supply	5	6
Data Processing	3	3
Total	85	76

SOURCE: Savell, Woelfel, and Collins (1975).

Table 4

PERCENTAGE OF NAVY ENLISTED WOMEN IN TRADITIONAL CAREER FIELDS

Career Field	1973 (N = 4835)	1974 (N = 7332)	1975 (N = 9597)
Medicine	38	32	32
Administration	29	26	27
Communication	9	13	16
Supply	9	8	9
Data Processing	4	4	3
Total	89	83	87

SOURCE: *Navy Military Personnel Statistics: Quarterly Reports*, 30 June 1973, 30 June 1974, and 31 March 1975.

nontraditional billets. If this hypothesis is valid, the traditional fields of medicine, administration, communications, and supply may be expected to become more feminized until the law prohibiting women on ships is repealed or reinterpreted.

Attitudes of Military Men Toward Women

It has been hypothesized that men seek all-male groups and form bonds that are resistant to female intrusion. Therefore, the reaction of male personnel to the shifting pattern of use of women has been of concern to the services because of the obvious implications for personnel effectiveness.

The Army conducted a survey of 721 soldiers, both male and female, in 1974 to determine their sex-role attitudes (Savell and Collins, 1975). Part of the study involved categorizing the respondents as traditional or contemporary on the basis of which of the following statements they agreed with:

1. Under ordinary circumstances, women belong in the home, caring for children and carrying out domestic duties, whereas men should be responsible for financial support of the family.
2. Relationships between men and women are ideally equal and husbands and wives should share domestic, child rearing, and financial responsibilities.

The subjects were also asked to indicate how they thought specified individuals and groups (i.e., the majority of men in the Army, the majority of women in the Army, their best friend of the opposite sex, and their best friend of the same sex) would respond. Table 5, which presents the results of this survey, indicates that respondents felt that women in the Army hold the most contemporary view (as indeed they do) and men the most traditional view (far more traditional than these men actually see themselves). This difference is striking, leading to the suspicion that the men privately held traditional views and willingly attributed these views to the majority of men in the Army. However, because they presumed their peers held a contemporary view, they were unwilling to describe themselves in unpopular terms. Both men and women considered themselves to be more contemporary in their attitudes toward female roles than their best friend of the same sex.

Table 5

PERCENTAGE ATTRIBUTING CONTEMPORARY SEX-ROLE ATTITUDE TO SPECIFIED INDIVIDUALS AND GROUPS

Referent	Overall (N = 721)	Men (N = 540)	Women (N = 181)
Women in the Army	85	83	84
Self	73	66	92
Opposite sex friend	70	71	63
Same sex friend	63	56	83
Men in the Army	29	37	22

SOURCE: Savell and Collins (1975).

Army researchers interpret this last finding to indicate that social value is placed on holding contemporary views of women's roles and that attitudes may be expected to become more consistent with this value with time.

Along with questioning attitudes toward women's place in society, the strength of job-relevant stereotypes of women held by Navy men was investigated by researchers at the Navy Personnel Research and Development Center. The concern is that such stereotypes are expressed as behaviors that affect the job satisfaction and retention of Navy women. Table 6 presents an analysis of the responses of 890 male recruits questioned in 1975. The five-point scale used in the questionnaire has been collapsed for simplicity of presentation, and the "undecided" response category is not included in the table. The chi square was computed for five response categories (4 D.F.), and all of the distributions of responses are significantly different from each other at the .01 level. The considerable number of young men (mean age = 19.6) who subscribe to these beliefs about women was unexpected. Such preconceptions as that women are more emotional than men and have less leadership ability could affect their future relationships with female supervisors and the types of duties and amount of responsibility given any women they might supervise. Yet, when this same group of recruits was asked three questions about equality of treatment in the areas of acquisition, training, and promotion, less than 10 percent stated that men and women should be treated differently.

An additional concern of the military is the reaction of men and civilians to the possible use of women in combat. Table 7 paraphrases the questions asked the groups but permits comparisons across sev-

Table 6

ATTRIBUTES OF WOMEN AS SEEN BY NAVY RECRUITS[a]
(Percent)

Attribute of Women	Agree	Disagree
Women more sickly	15	3[illegible]
Women more emotional	66	13
Women less logical	14	46
Women less decisive	21	44
Women less stable	36	33
Women less leadership ability	37	31
Women more easily influenced	30	31
Women less coordinated	8	68

[a]Chi squares are significant at the .01 level with [illegible] D.F.

eral samples. As shown, the group most resistant to placing women in a combat situation is the civilian sector. Army personnel are almost evenly split on the question (Segal, Kinzer, and Woelfel, 1975). Navy personnel exhibit two viewpoints, depending upon the identity of the sample. The recruits are indistinguishable from the 1973 civilian sample, despite their youth and the recency of the questionnaire. Fleet personnel, however, hold a more positive opinion of women's ability to perform in combat.

Table 7

ACCEPTANCE OF WOMEN IN COMBAT
(Percent)

		Agree	Disagree
1973 Civilian[a] (N = 560)	Only men should bear arms	74	26
1974 Army[a] (N = 724)	Women would be good combat soldiers	48	50
1973 Navy-fleet (N = 860)	I would want to be in combat with a woman	62	35
1975 Navy-recruits (N = 888)	I would want to be in combat with a woman	24	75

[a]Taken from Segal, Kinzer, and Woelfel (1975).

Research Findings for Navy Enlisted Women

The Navy currently is investigating the characteristics of females who enlist and their experiences in the male-oriented environment they encounter. Demographic data for almost 1,000 newly enlisted women were recently gathered as part of a longitudinal study (Thomas, 1976).

A profile of the composite female seaman recruit of 1975 shows that she is about 20 years old, comes from a city of less than 20,000 population, belongs to a family with four or more children, and rates her home as "happy most of the time." The typical female recruit lived at home until enlisting and feels that her parents' discipline and demands upon her were fair. Her decision to join the Navy was entirely her own and was firmly supported by her father, mother, and siblings, while her peers were evenly divided on whether she should join or not.

The three most important factors in her decision to enlist were (1) to make something out of her life, (2) to learn a new skill, and (3) to travel and meet people. The two least important factors were to help her family financially and to get away from home. She has no female friends in any of the services and admits to knowing very little about the military, but firmly subscribes to the statement, "In the Navy it is important to conform to the group wishes for the good of all."

Contrasts between the occupational goals of the sexes in the civilian literature indicate that in the world of work, males tend to be more interested in challenge and getting ahead, whereas females value friendly coworkers and pleasant surroundings. The Navy women who participated in the survey were asked to indicate from a list of 39 job factors those that were most important to them in making an occupational choice. Table 8 shows which factors the composite female considers essential or very important to her. The work values of a sample of approximately 1,000 male recruits, also surveyed in 1975, are included for comparison purposes (Thomas, 1976).

Table 8

WORK VALUES OF FEMALE AND MALE RECRUITS
(Percent)

Women (N = 997)		Men (N = 1,041)	
Provides a cheerful, clean work environment	67	Teaches a new skill or further develops one I already have	60
Gives me a feeling of really doing something important	63	Gives me a feeling of really doing something important	58
Teaches a new skill or further develops one I already have	62	Guarantees periodic raises, paid vacations, and sick leave	57
Includes a supervisor who cares about the worker's problems	59	Provides the opportunity to advance to a supervisory position	55
Helps others or in some way makes the world a little better place	57	Includes a supervisor who cares about the worker's problems	54

The first item shows that, like her civilian counterpart, the female Navy recruit highly values a cheerful, clean work environment. While it may be consistent with her image of the Navy's use of women, this value will cause her to experience dissonance if she is assigned to a nontraditional job. The second item shows that she values self-actualization to an even greater extent than do her male peers. Both sexes feel that learning a new skill and having a supervisor who cares about their problems are of considerable importance. The fifth item reinforces the picture of a young woman with traditional female values.

These findings may explain some of the reluctance often noted on the part of military women to go into newly opened nontraditional job specialties. The profile of female recruits described above does not paint a picture of contemporary young women who are eager to enter new fields and compete with men. If such young women are indeed wanted, the Navy will have to make a conscious effort to recruit them.

The work values held by the 1975 male recruit seem to indicate that he is looking for basic security, which is probably a reflection of the high unemployment rate of his civilian contemporaries. However, he considers a supervisor who cares as important as guaranteed benefits, a finding that has important implications for military leadership.

The Navy's Human Resource Management Survey yields data that permit comparisons between the ways that male and female personnel perceive the military organization. In general, women react more positively than men to Navy management practices (Durning and Mumford, 1976). However, with increasing exposure and work experience, women become disproportionately disillusioned in the peer area, where a consistently positive trend is exhibited by men as they increase in pay grade. Figure 1 illustrates the pattern for Peer Work Facilitation, one of the four indexes under peer leadership in the survey. This index is composed of such items as, "To what extent do members in your work group help you find ways to improve your performance?" As shown, nonrated women are more positive than nonrated men on these items. However, they drop off slightly at the E-4 level, while there is no change in the attitudes of their male counterparts. Between E-4 and E-5, when the decision to reenlist usually occurs, the men who choose to stay predictably have more positive attitudes, whereas attitudes of women have leveled off. By E-6, women's perceptions of the organization have dropped well below those of men, who are showing a steady upswing. The data indicate that women at the E-6 level feel more isolated from the work group than those at lower pay grades, while men have an increased sense of team solidarity. This figure is representative of all four of the indexes in the peer leadership dimension. In every case, the line for men originates below that of women, crosses over, and climbs steeply. The analyses were based on 1,900 enlisted women and 22,000 men from all shore installations that have women and that have been surveyed.

As noted earlier, the absolute number of women in nontraditional military jobs has increased. Common sense would lead us to suspect that a certain amount of organizational and individual growing pains has accompanied this change. Accordingly, the Navy is investigating the problems that arise when women are assigned to formerly all-male work groups. On-site visits are being made by senior chief petty offic-

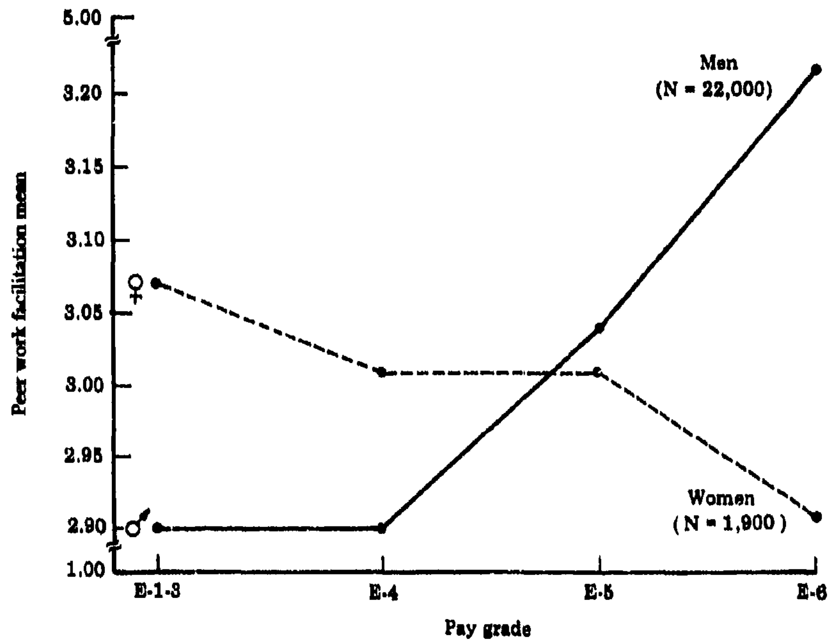

Fig. 1—Sex by pay-grade interaction, Peer Work Facilitation index

ers to selected commands to conduct interviews, to observe working and living conditions, and to determine what problems already have been resolved. To date, case histories have been developed for two air squadrons, an amphibious battalion, a harbor craft unit, and a submarine support facility. Although this project has not been completed, certain patterns are emerging.

When a command receives its first nondesignated women to replace nonrated men being rotated out, the initial reaction is to assign as many women as possible to traditional jobs—i.e., to the administration office or to the galley. When these options are exhausted, women have to be integrated into male work groups performing tasks that contribute to the primary mission of the command.

The men in these work groups typically respond in two ways. First, they engage in behavior designed to attract the attention of the opposite sex—i.e., they whistle, stare, and make sexist comments. Second, they assume that the women are incompetent. One woman reported being handed a paintbrush and bucket with explicit instructions as to which end you grasp and which end you dip. Once women make it clear that they do not intend to be viewed solely as sex objects and have as much familiarity with the task as a new nonrated male, the interaction within the work group typically changes to one of competition.

Competition between men and women can be very productive if it leads to cooperation. At the command in which the paintbrush incident occurred, which was primarily involved with physical labor out of doors, the women picked up the gauntlet. They became determined to demonstrate their capability and were fortunate enough to be supported by supervisory personnel all the way up the chain of command. If something was too heavy for one of them to lift, two of them did it. They learned new tasks quickly and well, displaying a high level of conscientiousness and competence. The methods developed by the women to compensate for their limited physical strength were adopted by the men, and the morale and productivity of the command increased.

Unfortunately, this scenario is not typical of the five case histories so far developed. At another command the research team visited, the rising competition between men and women was thwarted by unequal job assignments. Part of the unequal treatment was a result of the environment in which the command was located. Because berthing space for women was not available, it was exceedingly inconvenient for them to stand after-hours watches, and such watches were considered dangerous as there was a large number of transients on the base. This kind of inequity could have been dealt with if those in charge had exhibited a positive attitude toward using women in these duties. The officer in charge, however, was convinced that such assignments were inappropriate for women and that they could not perform at a satisfactory level. His chiefs were told to assign women to jobs they could handle and to make sure none of them damaged or were injured by Navy equipment. The women became dissatisfied with the restrictions, and their male peers started grumbling about the extra work and watch load. Fortunately, another officer, one with the attitude that women can and shall be used to the full extent of their abilities, has stepped into the picture and changes are occurring.

The behavior and attitudes of enlisted supervisory personnel who have never before had women working for them also is of interest. Several patterns are emerging. First, there are those chiefs who develop a paternalistic attitude, giving women any job they want to do and seeing that they are out of harm's way whenever a potentially dangerous activity is undertaken. Next, there are the supervisors who are dedicated to the concept that men and women are equal. They ask women to move 80-pound chains and mark their performance down if they are unable to do so. This kind of supervisor also frowns on women undertaking heavy jobs in pairs, since that takes one of them away from her assigned duties. The third type of supervisor seems to think that females in male jobs are a temporary phenomenon that he need not be concerned with. The good supervisor realizes that fairness is more important than equality when dealing with a wide range of human abilities. He follows the chain of command and resists the convenience of using a senior woman as an informal ombudsman. Most important, he recognizes that good leadership and management practices apply to women as well as to men.

The officers in the units in which women have been placed have had to make some difficult decisions. Women as a minority are distinct from racial or ethnic minorities because of real physiological differences and legal restrictions on their use. Moreover, the environment in which they have been thrust is totally male-oriented. Thus, a policy of sex-blind equality is generally acknowledged to be ill-advised and unrealistic. This raises the question of what types of sexual inequality should be considered fair. Further, to what degree should the inequality sanctioned by legislation and military regulations be considered unfair and open to arbitration?

One problem involves after-hour duty watches. Some watches require a berthing area for those on duty, but frequently there is none for women. Other watches require that areas in which personnel are sleeping be checked, which is against regulations for members of the opposite sex.

One unit handled the problem by using the separate-but-equal philosophy. Women could stand work area watches that secured by 2000, but late night and early morning watches were performed at a nearby women's barracks.

Another problem is discipline. Military women are rarely involved is the more serious violations of the Uniform Code of Military Justice, but some habitually report in late to work. Supervisors admit to being more lenient with women who are charged with unauthorized absence than they are with men. Commanding officers also admit to sexual bias in the area of discipline. They are familiar with and can counter the games men play at Captain's Mast, but women play by different rules.

The successful integration of women into nontraditional military billets is not simply a function of the attitudes of those involved. All of the services, but most particularly the Navy, are restricted from using women in the same manner as men. For the most part, newly desegregated jobs are related to combat activities, which was the rationale for segregating them originally. This often means that women may never fully participate with their unit, even in peacetime. These prohibitions against full use of women affect the dynamics within the work group and place a burden of understaffing on the command. For instance, women are assigned to an amphibious battalion in the Navy whose primary mission is assembling portable causeways and cranes to offload equipment from ships when a beach is being taken. Periodically, these units participate in naval operations to provide the full-scale practice needed for a quick-response capability. Since by definition beach landings occur from a ship, women may not participate in these operations. This situation leaves their work group shorthanded, sometimes to the extent that six men must perform the work of ten under simulated battle conditions. Thus, even commands that are quick to praise the women assigned to them do not want any more females while current restrictions are in effect.

CONCLUSIONS

What, then, does the future hold for military women? Only minor changes are expected until the Equal Rights Amendment (ERA) passes or the United States Code and relevant regulations are amended. The Army is within 15 percent of its 1980 goal of 50,000 WAC. The Navy has almost reached its goal of the 20,000 women that its planners consider the maximum tolerable under current restrictions on female use. Some grumbling already is being heard from male personnel that women are taking up the stateside billets and extending the foreign or sea duty for men. Although the presence of women probably has not affected normal rotation as much as civilianization of military jobs, it is true that if there were not as many women, men would be spending more time in the United States.

Three changes in the status of military women are imminent. First, the military academies will have women in the class of 1980 and subsequent classes. Second, the Air Force is following the Navy's lead and making preparations for the acceptance of women into noncombat flying jobs in the Military Airlift Command (MAC). Third, the Army will disestablish the WAC as a separate corps within the next two years. Also, female recruits will soon be receiving 50 to 70 hours of combat weapons training, in addition to the 20 hours of defensive weapons training currently required.

How will the passage of the ERA benefit military women? The services already have an exemplary record of job security and equal pay for all occupying the same rung on a career ladder, factors that are seen as very attractive to women in low-paying civilian jobs. Moreover, there are regulations designed to protect women from duties considered too dangerous, too arduous, or unacceptable by contemporary standards that will obviously be voided, as will other rulings that favor women. The possible loss of these protective rulings is spurring resistance to the equal-rights movement, both in and out of the military.

The major inequities between the sexes that are the target of social activists are in access to jobs and advancement to real leadership or decisionmaking positions. Because women cannot serve on ships, fly in most aircraft, or be assigned to combat units, their use is confined primarily to support billets. Passage of the ERA would remove all the restrictions, lift all the quotas, and void all the regulations applying to only one sex unless physical characteristics unique to one sex are relevant (The Equal Rights Amendment, 1973).

The changes will be far more involved than simple neutering of the language in regulations. Equality may be achieved by applying the standards for one sex across the board or developing new nonsexist standards. Whichever means is chosen, there may be far-reaching implications. For example, the military will have to decide whether to lower aptitude and educational standards for women or raise those of men. If supply and demand permit, raising the requirements for men would improve the quality of input to the military. However, how will the civilian economy employ the thousands of underage, lower-aptitude youth whom the services will be turning away?

Neutered job qualifications will have to be developed. Anthropometric standards will have to be established for many military specialties. Any standard that prevents the access of numerous members of one sex to a job will be open to legal challenge. Additionally, sexual bias in testing will become a far bigger equal-opportunity issue than racial bias. In January 1976, the services adopted a common set of recruit classification tests called the Armed Services Vocational Aptitude Battery (ASVAB). Familiarity with male-oriented subjects is needed to pass at least one-third of the subtests in the battery, such as the Electronics Information Test, the Shop Information Test, and the Automotive Information Test.

From the human resource management perspective, the resistance to these changes is difficult to understand. Women are acknowledged to be our greatest untapped and underused talent pool. Yet, to many in the military, they are anathema—not only because they threaten the cult of masculinity deemed necessary to forge a fighting force, but also because of the difficult problems that have to be solved before the armed services can be fully integrated. Until the laws and regulations are repealed, the dissonance experienced by military women will continue. It is a dissonance caused by being trained in skills they are prevented from using; by always being compared with the male norm and having to prove themselves by being better than a man; by having to be school-eligible in order to enlist but not being able to get into a school because the female quota is filled; and most of all, by conflicting policies that profess a military service based on equal opportunity for all but that discriminate against women in selection, classification, assignment, and advancement.

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THE EFFECT OF MILITARY EXPERIENCE ON POSTSERVICE EARNINGS WITHOUT THE DRAFT[1]

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A study has been made to determine the impact of military experience on post-service earnings in the absence of a draft. Previous studies of the effect of military service on veterans' earnings have concentrated on either the total population of veterans, who are said in four studies to be negligibly affected, or draftees only, who are said in three studies to be negatively affected. Although such results cannot be used directly to calculate earnings effects in the future, when all emerging veterans will be nondraftees, they do suggest that nondraftees may in the aggregate gain from military exposure. This is consistent with the notion that at least some nondraftees are "investors" who enlist in the hope of acquiring skills that will be transferable to civilian employment.

The human-capital methodology previously developed by the author is used to investigate the determinants, if any, of gains or losses in veterans' earnings resulting from a all-volunteer military and to assess the sensitivity of these results to military and training opportunities.

INTRODUCTION

This paper examines the effect of military experience on postservice earnings in the absence of conscription. Since the suspension of

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the draft in 1971, the issue of how military service affects subsequent civilian earnings has taken on additional importance. It has become necessary for the military to attract first-term servicemen solely on the basis of perceived present and future benefits of enlistment. If the earnings of nondrafted veterans (hereinafter called enlistees)[a] exceed those of comparable nonveterans by enough to make military service a profitable investment, this would be an important inducement to potential enlistees. Heretofore, this question has not been adequately investigated.

Previous studies of the effect of military service on the earnings of veterans have concentrated on either the total population of veterans, who are said to be negligibly affected (Browning, Lapreato, and Poston, 1973; Jurkowitz, 1968; Mason, 1970), or draftees only, who are said to be negatively affected (Cutright, 1973; Knapp, 1973; Miller and Tollison, 1971). Such results cannot be used to make direct inferences about earnings effects in the future, when all emerging veterans will be enlistees, since the populations sampled and the methodologies employed vary widely; however, they do suggest that enlistees may in the aggregate gain from military exposure. Such gains would be consistent with the notion that at least some enlistees are investors who enter the service in the hope of acquiring skills transferable to civilian employment.

The next section presents a general model that represents military enlistment as an investment (or disinvestment) in human capital. Then the data and the methodology used in estimating the model for the case of enlistees are described. Empirical results are discussed in the following section, and the paper concludes with a summary.

A HUMAN-CAPITAL MODEL OF MILITARY SERVICE

Let the earnings Y_t that an individual expects to receive in year t of his (civilian) working life be a function of his education experience E up to year t, his military experience M up to year t, and a set of personal characteristics X. The individual's expected earnings at experience level t are

$$Y_t = Y(E, M, t, X) . \quad (1)$$

In principle, the education experience variable E and the military experience variable M can each be thought of as binary variables, one

[a] This includes officers as well as nonofficers. Since the overwhelming majority of veterans are nonofficers (96.8 percent in the sample used in this study), little accuracy is sacrificed in labeling the whole group as enlistees.

for each year up to t, that indicate whether the individual was in school or in the military in that year. The variables E and M together describe an individual's "military-education experience." The personal characteristics set X represents the features of an individual that may affect earnings independently of education and military service at t.

In the population of enlistees, the earnings function, Eq. (1), allows representation of the change in the present value of future earnings attributable to military service. Let

E_i = the i^{th} educational experience ($i = 1, \ldots, n$),
M_j = the j^{th} military experience ($j = 0, 1, \ldots, m$),
M_0 = no military experience, and
X_e = the e^{th} set of personal characteristics ($e = 1, \ldots, p$).

An enlistee with educational experience E_i, military experience M_j (lasting q years), and a set of personal characteristics X_e expects an earnings change because of military service to occur in year t of his working life; this change is equal to what he would have earned had he not served (that is, had he undergone the "no military experience" M_0) and what he earns after undergoing military experience M_j. The difference may be represented by

$$\Delta Y_t = Y(E_i, M_j, t, X_e) - Y(E_i, M_0, t + q, X_e) .$$

Calculating the present value of ΔY_t at $t = -q$ (the beginning of military service) as $t = -q, -q+1, \ldots, 0, 1, \ldots R$ (where R is the last experience level for which $\Delta Y_t \neq 0$) yields the change in present value due to military service:[8]

$$\Delta PV = \sum_{t=-q}^{R} [(\Delta Y_t)/(1 + r)\, t + q], \qquad (2)$$

where r is a known discount rate, independent of time, and ΔPV can be interpreted as the change in human capital resulting from military service. The experience levels for which $\Delta Y_t < 0$ can be thought of as periods of human investment, and the experience levels for which $\Delta Y_t > 0$ represent the returns to that investment.

Although on a conceptual level this type of model is well suited for investigating the effects of military service, on a practical level there are important difficulties centering on the problem of whether comparable groups of veterans and nonveterans can be isolated. Two issues have been raised in this regard.

First, the earnings of veterans who leave the service may not be representative of the potential civilian earnings of veterans with

[8] If $t < 0$ for enlistees (i.e., during service), Y_t is set at military pay levels (see footnote 14).

seemingly identical military experiences who choose to remain in the military. One reason people may be drawn out of service is because they expect higher earnings in the civilian sector. Those who remain in service can thus be expected to have, on the average, lower civilian reservation prices.[4] Hence, the earnings of veterans may overstate the potential effect of the military on postservice earnings for all those who serve. This problem is known as selection bias (Grounau, 1973; Massell and Nelson, 1974).

Second, there is a question as to how precisely the variables in the earnings function (E_i, M_j, t, and X_e) can be specified. No matter how careful the specification, some variance in individual earnings will remain. Investigators can only attempt to capture, as well as possible, the deterministic portion of the earnings generation process and argue that the remaining variation in earnings is random.

The resolution of the selection bias problem also requires that the variables in the earnings function be specified as completely as possible. If the factors that determine whether or not military experience raises an individual's civilian opportunity cost enough to draw him out of the service are included in Eq.(1), then the earnings function can be viewed as a "reduced-form" equation that already accounts for the possibility of selection bias.

DATA AND METHOD

The data for this study are from a 1964 cross-section survey of 3,045 veterans and 6,548 nonveterans conducted for the Assistant Secretary of Defense for Manpower.[5] The veteran sample is a random sample of discharged servicemen aged 18 to 32, and the nonveteran sample is a random sample of men of the same ages who have never served. One attractive feature of the survey is that it specifically identifies draftees and nondraftees within the veteran sample. Veterans were asked if they would have entered the military in the absence of conscription. For purposes of this study, enlistees are defined as those who responded, "Yes, probably," "Yes, definitely," or "No idea" to this question. The total sample used in this study is composed of 6,964 observations—1,749 enlistees, and 5,215 nonveterans.[6]

The survey also has two serious shortcomings: First, the data are

[4] This assumes that veterans are, on the average, correct in their estimates of their civilian opportunity costs.

[5] See Klassen (1966) for a more complete description of the data.

[6] The size of the veteran sample is reduced principally because of the omission of drafted veterans The size of the nonveteran sample is reduced mainly because of missing variables.

from a 1964 cross-section. Since we are concerned with what happens to the earnings of enlistees over time, it is necessary to use the data as if they were longitudnal. It is assumed, for example, that after he has gained ten years of experience, an enlistee with five years of experience in 1964 will earn the same amount that an enlistee with ten years of experience (and identical other characteristics) earned in 1964. Use of cross-section data in this manner can introduce "cohort bias" (David, 1969; Stoikov, 1975), since it is unlikely that the earnings of everyone in the sample are independent of the year in which education or military or civilian training was received. Although this will cause some bias in the estimates of the experience-earnings profiles for both enlistees and nonveterans, no correction is undertaken, since our main interest is in difference in earnings rather than absolute earnings level. The biases introduced are less important in this case.[7]

Second, the survey includes veterans and nonveterans aged 18 to 32. No direct observations are available on the earnings of enlistees and nonveterans with otherwise identical earnings characteristics but whose age is greater than 32.[8] This, of course, represents an important constraint because if it is established that the earnings of the two groups differ, there is no reason to believe a priori that such differences will disappear before age 32. This problem is discussed further below.

To derive estimates of the earnings differences attributable to military service, it is necessary to estimate experience-earnings profiles for each of the military-education subgroups under consideration. The equation used to estimate these profiles is

$$\begin{aligned} \text{LN } Y_t = \; & b_0 + b_1(\text{VNV?}) + b_3 t + b_4 t^2 + b_4 [(t)(\text{VNV?})] \\ & + b_6 [(t^2)(\text{VNV?})] + b_6(\text{RACE}) + b_7(\text{UR?}) \\ & + b_8(\text{MAR?}) + b_9(\text{ME}) + u_t \end{aligned} \tag{3}$$

where LN Y_t = the natural logarithm of earnings in year t of the working life,[9]

[7] If the experience-earnings profiles are considered in dollar terms, the estimates of the earnings difference will not be affected if both enlistee and dollar profiles are biased by the same dollar amount. If the experience-earnings profiles are considered in logarithmic terms, the estimates will be unaffected if both profiles are biased by the same percentage amounts.

[8] The data contain some earnings observations to age 34, but the number of enlistees from age 32 to 34 is so small that estimation in this range is unreliable. See Knapp (1973) for further discussion.

[9] Experience is calculated as age minus education minus length of military service minus five.

VNV? = a binary variable = 1 if an enlistee and 0 if a nonveteran,
RACE = a binary variable = 1 if white and 0 otherwise,
UR? = a binary variable = 1 if rural and 0 otherwise,[10]
MAR? = a binary variable = 1 if married and 0 otherwise,
ME = a binary-coded complex[11] representing the respondent's military-education experience, and
u_t = a random disturbance term with zero mean and constant variance.

Some discussion of Eq. (3) is in order. The VNV? variable is included to reflect potential differences in earnings between comparable enlistees and nonveterans. The experience (t) and experience-squared (t^2) variables are designed to capture the influence of the civilian postschool investment process and allow estimation of the relevant age-earnings profiles. Interaction terms between each of the experience variables and VNV? are included to allow for differences between the slopes of the experience-earnings profiles of enlistees and those of nonveterans.

Three socioeconomic background variables are incorporated in Eq. (3). The RACE variable is designed to standardize for the quality of the opportunities available to the respondent. It is hypothesized that the opportunities available to whites are superior to those available to nonwhites, with respect to both formal and informal training. Respondents currently residing in urban areas are expected to have higher earnings because of the genrally higher wages in urban areas. It is expected that married respondents will have higher earnings because of the additional effort required to support a family.

Although it is desirable to specify the earnings function as completely as possible, including more variables in the set of personal characteristics is unlikely to add much explanatory power to the equation. Furthermore, since the other socioeconomic variables available in the survey are highly correlated with each other and with the three variables discussed above, their inclusion could cause serious statistical estimation problems, namely multicollinearity. The three variables selected represent the resolution of competing objectives. They are assumed to be generally independent of each other and to adequately represent the characteristics that affect earnings outside of experience, military service, and education.

[10] Rural is defined as all nonincorporated places and incorporated places with less than 2500 inhabitants.

[11] A binary-coded complex is a set of binary variables representing a set of possible events with a finite number of alternatives.

The ME variable is a binary-coded complex that depicts the respondent's military-education experience. The form taken on by the ME variable will depend on which of two potentially interesting hypotheses concerning the effect of military service and formal education on earnings is under consideration. To test such hypotheses it will be necessary to compare estimations of Eq. (3) under alternative specifications of ME. For example, to test whether it matters if education is received before or after military service, Eq. (3) must be estimated with and without this factor being accounted for.

EMPIRICAL RESULTS

Regression estimates for three alternative specifications of Eq. (3) are presented in Table 1. Consideration of these three specifications is necessary to determine which form of the ME variable (the military-education binary-coded complex) best represents, in as simple a manner as possible, the joint effect of education and military service on earnings. The following hypotheses were tested:

a. Whether an enlistee's education is completed before or after service is *not* a statistically significant determinant of earnings.
b. The difference between the effect of education on earnings for enlistees and that for nonveterans is *not* statistically significant.

In regression (3a) of Table 1, binary variables are included to represent the eight military-education categories indicated. The base case category is nonveterans with a high-school education or less.[12] In Eq. (3b), the number of binary variables is reduced to five by eliminating differences in the timing of education, also shown in Table 1. To test hypothesis a, an F-statistic is calculated using the error sums of squares in Eqs. (3a) and (3b). Similarly, hypothesis b is tested by deletion of binary variables as illustrated in regression estimates (3c) of Table 1.

The results of these F-tests are reported in Table 2. As can be seen, at both the .01 and .05 significance levels, hypothesis a is accepted, while hypothesis b is rejected. This is evidence that Eq. (3b) of Table 1 is the most appropriate specification of the joint effect of education and military service on earnings. Whether education is completed before or after service is not a statistically significant determinant of

[12] The effect of the three socioeconomic binary variables is also included in the equation's intercept term.

Table 1

REGRESSION ESTIMATES
(Dependent variable = Ln Y_t; standard errors in parentheses)

Independent Variables	Estimating Equation (3a)	(3b)	(3c)
Constant	6.0623	6.0627	6.1076
VNV?	1.4871**	1.4856**	.9463**
	(.1279)	(.1279)	(.0609)
t	.2256**	.2257**	.2235**
	(.0061)	(.0061)	(.0061)
t^2	-.0079**	-.0079**	-.0079**
	(.0003)	(.0003)	(.0003)
(t) (VNV?)	-.1554**	-.1551**	-.1529**
	(.0140)	(.0140)	(.0141)
(t^2) (VNV?)	.0050**	.0050**	.0059**
	(.0007)	(.0007)	(.0007)
RACE	.2539**	.2533**	.2598**
	(.0255)	(.0285)	(.0287)
UR?	-.1765**	-.1768**	-.1820**
	(.0180)	(.0180)	(.0181)
MAR?	.5312**	.5303**	.5514**
	(.0228)	(.0228)	(.0228)
ME-equation (3a)[a]			
NVET-COLL	.6431**	..	..
	(.0211)		
NVET-GRAD	1.1788**	..	..
	(.367)		
ENLT-HS/HS	-.1677	..	..
	(.1131)		
ENLT-HS/COLL	.0691	..	..
	(.1103)		
ENLT-HS/GRAD	.5205*	..	..
	(.2131)		
ENLT-COLL/COLL	.1368	..	..
	(.1114)		
ENLT-COLL/GRAD	.3727**	..	..
	(.1282)		
ENLT-GRAD/GRAD	.5603**	..	..
	(.1432)		
ME-equation (3b)			
NVET-COLL	..	.6434**	..
		(.0211)	
NVET-GRAD	..	1.1792**	..
		(.0368)	
ENLT-HS	..	-.1677	..
		(.1131)	
ENLT-COLL	..	.1193	..
		(.1108)	
ENLT-GRAD	..	.4442**	..
		(.1213)	
ME-equation (3c)			
COLL	..	..	.5704**
			(.0191)
GRAD	..	..	1.0581**
			(.0324)
n	6964	6964	6964
R^2	.5895	.5892	.5842

Note: * = significant at the .05 level; ** = significant at the .01 level.

[a]The variables in the ME binary-coded complex should be interpreted as follows: The first term denotes either a nonveteran or an enlistee (NVET or ENLT). The second term denotes the educational level, either HS (high-school education or less), COLL (some college but no degree), or GRAD (a college degree or greater). If a slash is included, the term on the left side denoted education before service and the term on the right side denotes education after service. In Eq. (3c), only educational levels are considered.

Table 2

TESTS OF HYPOTHESES

Hypothesis a:		
H_o: Whether education is completed before or after service is not a statistically significant determinant of earnings		
H_a: Not H_o		
Calculated F = 1.63	$F^3_{6948}(.01) = 3.78$	Accept H_o
	$F^3_{6948}(.05) = 2.60$	Accept H_o
Hypothesis b:		
H_o: The difference in the effect of education on earnings between enlistees and nonveterans is not statistically significant		
H_a: Not H_o		
Calculated F = 27.79	$F^3_{6951}(.01) = 3.78$	Reject H_o
	$F^3_{6951}(.05) = 2.60$	Reject H_o

earnings, but the effect of education on earnings is different for enlistees and for nonveterans.

The acceptance of hypothesis a is in contrast to previous results, which established that, other things being equal, there is a gain in future earnings for draftees who continue their education after service over those of comparable draftees with the same final education attainment who complete their education before service (Knapp, 1973). Apparently, for these people the induction process enhances the value of additional years of education. The contrasting result for enlistees may be due to differences in the types of military training received by the two groups. Normally, the training of draftees is of only general civilian applicability. Draftees are said to learn such nebulous qualities as discipline, ability to get along with others, and good citizenship. Such general training is of less value when it follows the more specific training of formal education. The military training of enlistees, however, tends to be more specific. The order in which military training and formal education occur for enlistees may therefore be inconsequential.

The rejection of hypothesis b indicates that the effect of education on earnings is sensitive to whether the individual is an enlistee or a nonveteran. Taking this result in conjunction with the statistical significance of the estimated coefficient on the VNV? variable, it is possible to conclude that, overall, enlistment is a statistically significant determinant of earnings.[13] Although it is tempting to add the estimated coefficient on the VNV? variable (+1.486) to each of the estimated coefficients on the enlistee military-education binary variables and label this as the joint effect of enlistment and education on earnings, it is impossible to make such an interpretation independently of the interaction of enlistment with experience in the equation. Only when the estimates of the age-earnings profiles for enlistees and nonveterans by educational groups are derived below will a straightforward interpretation of the full effect of enlistment be posible.

An attempt was made, in a regression not reported here, to decompose the VNV? variable into five separate binary variables representing the various service branches (Army, Navy, Air Force, Marines, and Coast Guard) to investigate whether this part of the estimated effect of enlistment varies by branch. The hypothesis that branch is not a statistically significant determinant of earnings was accepted at the .01 significance level.

The other estimated coefficients in Eq. (3) are consistent with expectations. The estimated coefficients on the three socioeconomic variables each have the expected signs and are statistically significant. The estimated coefficients on the four experience-related variables are also statistically significant, but again it is difficult to give them any meaningful interpretation that is independent of the estimated age-earnings profiles. Let us now turn to the estimation of those profiles.[14]

The estimated age-earnings profiles derived from Eq. (3b) are shown (in absolute dollar terms) in Fig. 1.[15] Age-earnings profiles were calculated for enlistees and nonveterans for each of the three educational categories, HS, COLL, and GRAD, as defined in Table 1. The nonveteran profiles were calculated using the mean values of the socioeconomic variables for enlistees within each educational catego-

[13] The statistical significance of the enlistment-related experience variables also supports this conclusion.

[14] Age-earnings rather than experience-earnings profiles are used to compare enlisted and nonveteran earnings, since enlistees and nonveterans of the same age will have experience levels differing by the length of military service. The method for calculating the age-earnings profiles is discussed in footnote 15.

[15] Nonveterans with HS, COLL, and GRAD educational levels are assumed to start work at ages 18, 20, and 22. Enlistees are assumed to enter the service after education and remain in the military for the average number of years calculated within each educational category. These averages were 2.4, 2.8, and 2.7 for the HS, COLL, and GRAD educational classifications, respectively. Enlistee earnings are assumed equal to the weighted average of officers' and nonofficers' earnings within each educational category. Earnings for officers and nonofficers were set at the 1964 levels of approximately $4800 per year for officers and $2400 per year for nonofficers. Military earnings are now higher in real terms.

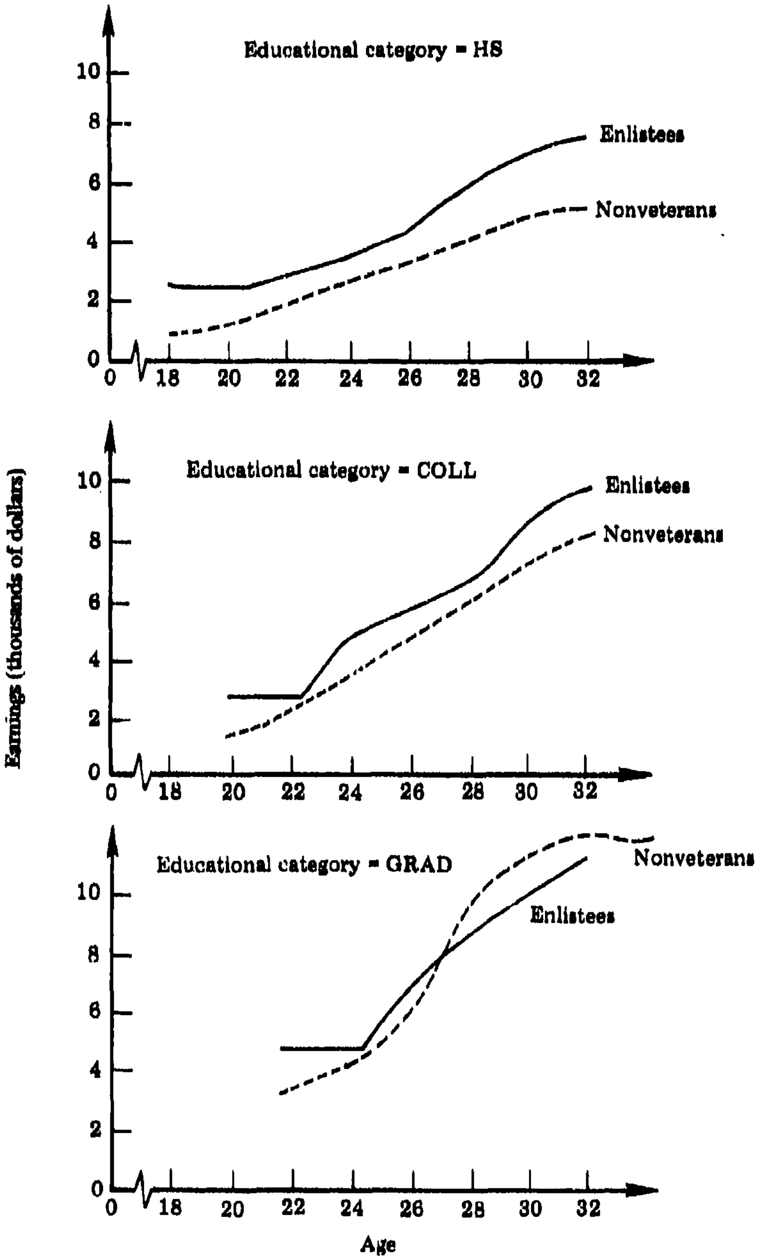

Fig. 1—Age-earnings profiles for enlistees and nonveterans by educational category

ry,[16] since differences in the estimated profiles should reflect the effect of enlistment and not that more enlistees than comparable nonveterans are white, urban, and married.

Before the dollar effect of enlistment within educational categories can be estimated, it is necessary to deal with the problems presented by the limited range of the age variable (see the discussion above). Casual investigation of the profiles depicted in Fig. 1 shows little tendency toward convergence, except perhaps in the highest educational category (GRAD). There is empirical evidence to support this conclusion. In regressions not reported here, the hypothesis that earnings are equal for enlistees and nonveterans was tested for three age levels (less than 25, 25 to 30, and greater than 30). In all cases the equality hypothesis was rejected at both the .01 and .05 significance levels. It is especially noteworthy that the hypothesis was rejected for the highest age level, since this implies that the profiles had not converged before age 32.

Although the profiles for the lower two educational categories considered in Fig. 1 (HS and COLL) show some tendency to diverge at later ages, from a theoretical standpoint that is unlikely. Whatever the relationship is between enlistment and the postschool investment process, it is unclear why it should lead to an ever-expanding dollar gap between the profiles. Unfortunately, there is no way to test this proposition statistically.

As a compromise solution to this problem, we have assumed that the dollar earnings gaps within each educational category remain constant after age 32 at a level equal to the average of the earnings gap for the previous five years. Since the estimates thus derived of the gap in earnings past age 32 are clearly less reliable than the estimates of the gaps before age 32, they are reported separately. In defense of this technique, it should be noted that at positive discount rates, earnings gaps in the older age range will be less important quantitatively than those before age 32.

Table 3 presents estimates of the ΔPVs (see Eq. (2)) attributable to enlistment for each of the three educational categories HS, COLL, and GRAD. The estimates are presented at 0, 5, and 10 percent rates of discount.[17] The results show that enlistment is profitable for the lower two educational categories (HS and COLL) in that the ΔPVs are positive at all rates of discount. The ΔPVs are all negative for the GRAD educational category. It can consequently be argued that for the lower two educational categories, enlistment is a good human

[16] The MAR binary is allowed to vary according to the average value reported for each value of experience within educational categories.

[17] All individuals are assumed to retire at age 65.

Table 3

Estimates of the Change in Net Present Value (ΔPV) Attributable to Enlistment
(In dollars)

Educational Category (discount rate, %)	ΔPV Before Age 32	ΔPV After Age 32	Total
HS			
(0)	28,195	86,432	114,627
(5)	19,135	21,559	40,694
(10)	13,973	6,774	20,747
COLL			
(0)	8,436	33,088	41,524
(5)	6,429	9,099	15,528
(10)	4,543	3,111	7,654
GRAD			
(0)	-449	-28,704	-29,153
(5)	1,184	-8,704	-7,520
(10)	1,592	-3,293	-1,701

investment when the training received is transferable to civilian life in terms of increased average earnings. This should prove to be a substantial inducement to potential enlistees, but the argument cannot be made for college graduates.

Table 3 also indicates that the profitability of enlistment as a human investment declines with education. This is not surprising. It is problematic whether the gain in enlistees' earnings comes from training for specific job skills that are transferable to civilian employment or from more general training opportunities, but in either case the process would be of less value as the individual's education increases. With respect to specific training, the job skills usually taught in the military (e.g., electronics, mechanics) are not normally thought of as complementary to a college education. With respect to general training, the desired qualities (e.g., leadership) may be obtainable directly by attending college without enlistment.

SUMMARY

This paper has examined the effect of military experience on postservice earnings in the absence of a draft. A theoretical model is proposed where the civilian earnings of enlistees are compared with those of otherwise comparable nonveterans. The regression estimates of the model imply that although the stage at which education is completed—i.e., before or after service—is not a statistically significant determinant of earnings, the effect of education on earnings is sensitive to enlistment. Taking this result together with the statistical significance of the estimated coefficients on other enlistment-related variables, it is possible to reach the general conclusion that enlistment is a statistically significant determinant of earnings.

Estimated age-earnings profiles are subsequently used to calculate the change in the net present value of future earnings attributable to enlistment. This change is positive for enlistees without college at all discount rates considered, but negative for enlistees with college degrees. The profitability of enlistment as a human investment declines uniformly as education increases.

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MILITARY OCCUPATION, GI BILL TRAINING, AND HUMAN CAPITAL

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A unique data file has been assembled to focus on the effects of both military training and GI Bill training on post-service earnings capacity. Data files from the DoD, the Veterans Administration, and the Social Security Administration are merged, producing a micro-dataset containing longitudinal earnings profiles (covering the period 1955-1974) for about 70,000 enlisted men who separated from active duty during FY 1969. It also contains detailed information for each individual on personal characteristics and in-service and post-service experiences, including details of participation in the GI Bill. A preliminary cross-tabulation analysis of the net effects of military training and GI Bill training on lifetime earnings capacity, both in the aggregate and for various subgroups of interest is presented.

INTRODUCTION AND SUMMARY OF FINDINGS

The economic relationship between the military and civilian sectors of a society has been a topic of long-standing interest both to economists and to the general public. Historically, most of the attention has been focused on very broad magnitudes, such as the choice between "guns and butter," but recently the more subtle relationships are coming under scrutiny. In the debate over the move to an all-volunteer force, the subtle "tax in kind" that a system of conscription imposes on draftees played an important role in the decision to end the draft.

In this paper we examine perhaps the most subtle relationship between the military and civilian sectors of our society: Through the

GI Bill program and in-service occupational training, the military sector may be able to make significant alterations in the size and composition of the stock of human capital available to the civilian sector.[1] By human-capital formation, economists mean all those activities that improve future earning capacity.[2]

The GI Bill educational entitlements program and the very large program of in-service occupational training given to first-term enlisted personnel are the two most important military-related activities that affect the size and composition of the stock of civilian sector human capital. The GI Bill subsidy has enabled millions of veterans to participate in a variety of postsecondary education or training programs. The three major types of programs are college, vocational and technical (voc-tech) training, and on-the-job training (OJT).

Analysis of the human-capital effects of these two military-related activities is particularly timely. The premises underlying the GI Bill program—large-scale conscription and involvement in war—are no longer pertinent. Pressures are building to end the program; President Ford has recommended its elimination. [EDITOR'S NOTE: Since this paper was originally written, the GI Bill has been changed by the passage of Public Law 94-502, but not eliminated. From the viewpoint of the discussion here, the most important change was the introduction of a cost-sharing arrangement between the Department of Defense and the service member for future educational benefits. The basic points in this paper nevertheless remain valid.] Knowledge of the effects of the program is therefore particularly important. Will the end of the Bill lead to a decline in the rate of human-capital formation? Will human capital become more or less equally distributed? What effect will elimination of the Bill have on the military recruiting effort? Analysis of the contribution of in-service occupational training to earning capacity is useful here. Information on the extent to which veterans use in-service occupational training in the civilian sector and the return to using this training is highly relevant to a post-GI Bill environment.

This study uses a unique longitudinal data file on approximately 70,000 first-term enlisted men who separated from active duty in FY 1969. Data from the Department of Defense (DoD), the Veterans Administration, and the Social Security Administration were merged to create a file containing, for each individual, a host of personal characteristics, military experience information, details of GI Bill partici-

[1] The findings presented in this paper on the GI Bill are excerpted from an ongoing study by O'Neill and Ross funded by the U.S. Department of Labor.

[2] For the seminal work on human capital, see Becker (1964).

pation, and annual earnings covered by Social Security for each year from 1951 to 1974.[a]

Using these data and supplementary data from the Veterans Administration and from the Manpower Resources Data Analysis Center (MARDAC), the next section focuses on trends in use of the GI Bill, the socioeconomic characteristics of users of the Vietnam-era Bill, and the earnings effects from use of the Bill for voc-tech training and OJT. Next, we analyze the propensity of nonusers of the GI Bill to use their military occupational training after service and the effect of use of military training on postservice earnings.

Participation in the GI Bill program since World War II has been rising, and participation in the Vietnam-era program will ultimately be considerably higher than participation during the programs of earlier war eras. Further, different socioeconomic groups of veterans have different propensities to participate in the program; and the type of training for which these groups use their benefits varies considerably. Most important, black veterans have a higher participation rate than nonblack veterans in the same education and AFQT score category, and a higher percentage of blacks than nonblacks use their benefits for college attendance.

Among those individuals, the choice between not using the GI Bill and using it for OJT or voc-tech training depends upon the job opportunities open when the person leaves the service. Those with good job opportunities either do not use the GI Bill or use it for OJT. Those with poor opportunities use it for full-time voc-tech training. Among the veterans with poor job opportunities, use of the GI Bill for voc-tech training was found to add to earning capacity.

When the effect of the GI Bill on differences in earnings by race was examined, voc-tech training was found to add more to the earning capacity of blacks than to that of nonblacks; OJT added at least as much to the earning capacity of blacks as of nonblacks.

A tentative conclusion is that the GI Bill program may have important distributional consequences. A full evaluation will require analysis of the effect of college training on the earning capacity of people with different characteristics. But the findings in this paper indicate that noncollege uses of the GI Bill, especially voc-tech use, have a greater positive effect on the earning capacity of veterans with poorer personal characteristics and poorer postservice job opportunities than on that of other veterans. Those charged with deciding on the elimination of noncollege uses of the GI Bill will have to deal with this fact.

Analysis of the occupational choices and postservice earnings of veterans who did not use the GI Bill yields several important findings.

[a] For a description of these data, see O'Neill and Ross (1975).

First, those trained in the higher-skilled military occupation categories (e.g., Electronics Equipment Repair) are more likely to go into civilian occupations related to their military occupation than individuals trained in the lower-skilled categories (e.g., Supply/Service Handlers). Second, in some categories, military occupational training appears to add substantially to earnings capacities. Those trained in four high-skilled occupation categories who went into related civilian occupations after service were found to earn 7.1 to 12.5 percent more than those trained in the same occupation categories who went into unrelated civilian occupations. In the lower-skilled occupations, use of occupational training in the civilian sector was not associated with higher earnings. It is evident that certain types of military occupational training may be close substitutes for occupational training obtained under the GI Bill.

THE GI BILL

The GI Bill provides a sizable subsidy to human capital formation. One important policy issue is whether this subsidy, when viewed as a social investment, has a payoff. Does it enhance an individual's earning capacity? Our earnings data will not allow us to address this question for college use of the GI Bill, but we can address it for noncollege uses.

An equally vital policy issue deals with the distributional implications of the GI Bill. Does it benefit groups who would have had high earnings anyway, or are less advantaged groups the primary beneficiaries? The Bill may differentially benefit different socioeconomic groups to the extent that (1) groups have different participation rates in the GI Bill program, or (2) education or training obtained under the Bill adds differentially to the earnings capacities of the different groups.

Participation Since World War II

Since the end of World War II there have been three GI Bills. The World War II Bill began in June 1944 and covered veterans who had served between September 1940 and July 1947. The Korean Conflict Bill began in August 1952 and covered veterans who had served on active duty between June 1950 and January 1955. The current Post-Korean Bill began in June 1966 and covers veterans who served on active duty between January 1955 and August 1964 and Vietnam-era veterans who served on active duty after August 1964. The latest Bill is still in force (1976) and is applicable to all individuals entering the armed services. [EDITOR'S NOTE: Individuals entering after December 31, 1976, are covered by the GI Bill represented in Public Law 94-502.] Except for the three years following World War II (July 1947 to June 1950), then, active duty service in the military has carried with it the opportunity to obtain postservice educational or training benefits.

The data in Table 1 show the number and percent of military personnel participation in each of the three Bills and the distribution of participants among the types of training subsidized by the Bills. Two trends are apparent: The first is a rising overall rate of participation in the program. The percentage of veterans eligible for the Vietnam-era Bill who have used their entitlements is 59.3. This percentage is somewhat higher than those for earlier eras. More important, the percentage difference in participation rates of Vietnam-era veterans and veterans of other eras will widen in the future. The programs of other eras have terminated, but the 10-year period of entitlement eligibility has not expired for any Vietnam-era veterans. When it expires, considerably more than 59.3 percent will have used their benefit entitlements.

The second trend is the change in the way entitlements are used. College use of the Bill has been rising. Most of this change occurred between the World War II and Korean War bills, but the percentage using the Bill for college has continued to rise since the Korean Conflict Bill.

Table 1

COMPARISON OF CUMULATIVE PARTICIPATION RATES AND TYPES OF TRAINING SELECTED UNDER THREE GI BILLS

Participation and Type of Training	World War II	Korean Conflict	Post-Korean Conflict	Vietnam [a] Era Only	"Peacetime"[a] Post-Korean Only
Total veteran population	15,440,000	5,509,000	10,689,000	7,597,000	3,092,000
Percent ever in training	50.5%	43.4%	54.1%	59.3%	41.4%
Total ever in training	8,000,000	2,391,000	5,785,648	4,505,933	1,281,715
Percent distribution by Type	100.0%	100.0%	100.0%	100.0%	100.0%
College	28.6	50.7	53.5	54.2	51.0
Other schools	44.6	36.0	37.9	36.4	43.1
On-the-job training	17.9	9.3	8.0	8.9	4.7
Farm trainees	8.8	4.0	.6	.4	1.1

SOURCE: *Information Bulletin*, Dept. of Veterans Benefits, Veterans Administration, DVB IB 20-75-9, June 1975, Appendix B, Table 11, p. 49.

[a] These two columns are a decomposition of the column entitled Post-Korean Conflict.

Participation in the Vietnam Era

Participation in the GI Bill program by various subgroups of Vietnam-era veterans has been analyzed to provide some clues about the distributional consequences of the program. Table 2 presents the percentage of participants when veterans are cross-classified by race, education level, and Armed Forces Qualification Test (AFQT) score. The data in Table 2 are for enlisted personnel who left the service after July 1968 and used the benefits before March 1974.[4] Table 2 presents the first known racial breakdown of GI Bill participation.

The findings in Table 2 are surprising. Although blacks and nonblacks have about the same overall participation rate, a higher percentage of blacks participate in the program in every education and AFQT score cell. Depending upon the category chosen for comparison, 4.5 to 9.9 percent more blacks than nonblacks use their GI Bill entitlements.

The data in Table 2 also indicate that those with higher education and AFQT scores are more likely to use their entitlements than those with lower education and AFQT score. Use of GI Bill entitlements to add to one's human-capital stock is positively related to the stock one already has. There are no overall racial differences in participation, even though there are differences within cells because proportionately more nonblacks are in the higher-education and AFQT score cells where participation rates are higher.

In addition to the participation rate, another dimension of use is the amount of entitlement used by different subgroups. Table 3 presents the median number of months of entitlement for the various subgroups.[5] Racial differences are not quite as evident here as in the participation data. However, among those with 12 years of education, blacks have more months of use than nonblacks with similar AFQT scores. In other education and AFQT score cells, blacks and nonblacks generally have similar months of use.

The median months of use rise with education level and AFQT score. Again, those with a large initial human-capital stock appear to have a higher rate of participation in the GI Bill program and draw benefits for longer periods of time than those with smaller initial stocks.

Table 4 presents, for the various subgroups, the distribution of participants by type of training activity. Significant differences among

[4] The overall percentage of participants is lower in Table 2 than in Table 1 primarily because Table 1 runs through June 1975.

[5] The median months of use understate how long individuals will ultimately draw benefits. Some people were still drawing benefits as of March 1974; any may draw more benefits in the future if they have not exhausted their benefit entitlement.

Table 2

Cumulative Percent Ever Participating in GI Bill Training as of March 1974, Vietnam-Era Veterans Who Separated from Active Duty after June 1968, by Color, Schooling, and AFQT Score
(Number of observations in parentheses)

Education	AFQT Score <31	AFQT Score 31-46	AFQT Score 47 +	By schooling[a] and for all
Blacks				
Nongrads	38.7 (41,700)	43.2 (9,899)	45.1 (3,392)	40.2 (63,146)
High-school grads or more	48.1 (120,012)	55.3 (50,247)	61.3 (40,384)	53.9 (230,646)
All				50.9 (293,792)
Nonblacks				
Nongrads	29.5 (145,609)	33.3 (84,908)	38.8 (87,602)	33.6 (360,732)
High-school grads or more	38.9 (228,337)	45.4 (340,208)	56.8 (1,591,455)	53.1 (2.349,124)
All				50.5 (2,709,856)

SOURCE: Cross-tabulations provided by MARDAC, Office of the Assistant Secretary of Defense for Manpower and Reserve Affairs.

[a] The overall percentages include individuals with unknown AFQT scores.

Table 3

Median Number of Benefit Months Used as of March 1974 Among a 10 Percent Sample of GI Bill Participants Separated from Active Duty During FY 1969, by Race, Schooling, and AFQT Score
(Number of observations in parentheses)

Years of Education	Nonblack AFQT Score <31	Nonblack AFQT Score 31-46	Nonblack AFQT Score >46	Black AFQT Score <31	Black AFQT Score 31-46	Black AFQT Score >46
<12	4.1 (800)	4.6 (687)	7.8 (743)	4.6 (221)	4.6 (108)	5.2 (37)
12	9.6 (1,783)	11.9 (3,810)	18.5 (16,799)	13.2 (1,215)	15.2 (716)	19.8 (568)
13-15	17.7 (71)	19.4 (247)	20.6 (3,401)	17.1 (82)	16.8 (61)	20.4 (89)
16+	a (5)	10.2 (44)	12.2 (784)	a (10)	11.5 (23)	18.5 (31)

SOURCE: The Vet-Merge File.

[a] Ten or fewer observations.

the subgroups are evident. For example, at all AFQT score levels, blacks are more likely than nonblacks to use the GI Bill for college-level training. They are also more likely than nonblacks to use the Bill for voc-tech training, but less likely to use it for OJT. It is also clear from Table 4 that a higher proportion of individuals with high AFQT scores use the Bill for college. Those with low education and AFQT scores are somewhat more likely to use the Bill for voc-tech training.

Earnings Effects of Noncollege Training

Our unique longitudinal data file is used in this section to examine whether voc-tech training and OJT obtained under the GI Bill have increased individuals' earning capacities. Before presenting our findings, let us examine briefly what the earnings profiles should look like relative to those of the nonusers, under the hypothesis that users are making human-capital investments. According to the human-capital theory (see, e.g., Mincer, 1974), the earnings of users will lie below those of nonusers during the years of training and the early years following training but will overtake and surpass the earnings of nonusers at some later date. One reason these longitudinal data are so useful is that the pattern of earnings of users and nonusers can be traced over time, which is impossible with cross-sectional data. If there is a tendency for the earnings profiles of voc-tech and OJT users to lie below, overtake, and then surpass the profiles of nonusers, the tendency should be apparent in these data.

Before we discuss detailed earnings-profile comparisons between voc-tech and OJT users and nonusers of the GI Bill, we present some summary earnings profiles for various subgroups in Table 5. The number of observations on which each yearly earnings average is based is given in parentheses. The earnings profiles in Table 5 generally conform to expectations. Earnings rise with education level and AFQT score and are higher for nonblacks than for blacks. The table also indicates that nonusers of the GI Bill earn more than all users. There is a slight tendency toward overtaking: The earnings difference between users and nonusers is diminishing over time.

The earnings profiles for GI Bill users in Table 5 are for all types of training. To look at the noncollege types of training, the average yearly earnings of voc-tech and OJT users were computed for 1970 through 1974, by the year in which a person terminated training.[6] Tables 6 and 7 present the average yearly earnings of voc-tech and OJT users. For convenience, Fig. 1 graphs the earnings profiles of several selected user groups as well as the nonuser profile.

[6] It is too early to examine the earnings of college users. Many were still in school as of March 1974, and those who had left were not in the labor market long enough for any earnings effect of their education to show up.

Table 4

DISTRIBUTION BY TYPE OF TRAINING[a] OF PARTICIPANTS WHO SEPARATED FROM ACTIVE DUTY DURING FY 1969, BY RACE, SCHOOLING, AND AFQT SCORE
(Percent distribution)

	Nonblack						Black					
	AFQT Score						AFQT Score					
	< HS			HSG +			< HS			HSG +		
Type of Training	<31[b]	31–46	47 +	<31	31–46	47 +	<31	31–46	47 +	<31	31–46	47 +
College level	13.8	19.1	31.5	39.6	46.4	61.4	19.9	27.3	38.4	48.7	56.5	66.8
Voc/tech institutions	22.5	20.8	17.9	19.5	15.4	9.3	33.2	31.3	22.5	30.4	22.2	12.9
OJT	20.0	19.9	19.3	17.2	18.0	13.8	14.8	14.4	14.1	7.8	9.8	10.3
All correspondence	36.0	34.7	28.0	22.5	19.8	15.4	20.4	17.6	16.7	12.3	10.3	9.5
Other	7.6	5.5	3.2	.7	.4	.1	11.7	9.4	8.3	.8	.7	.4
Number of observations	8,484	7,168	7,615	17,770	39,593	209,459	2,744	1,044	396	12,247	7,938	6,737

SOURCE: Cross-tabulations provided by MARDAC, Office of the Assistant Secretary of Defense for Manpower and Reserve Affairs.

[a] The type of training is the one the veteran was enrolled in at the time of most recent termination or the one he is currently enrolled in.

[b] Columns may not add to 100 percent due to rounding.

Table 5

Estimated Longitudinal Annual Earnings Profiles for Various Subgroups in the Vet-Merge File (1968-1974)

Subgroup	1968	1969	1970	1971	1972	1973	1974
By Participation Status							
(26,795) All users	2,586	4,196	5,011	5,525	6,611	7,817	8,410
(18,209) Users (term. only[a])	2,575	4,089	4,865	5,458	6,707	8,256	9,035
(26,067) All nonusers	2,673	5,305	6,531	7,231	8,292	9,450	9,878
By Color							
(5,091) All blacks	2,417	4,147	5,059	5,513	6,410	7,270	7,378
(50,975) All nonblacks	2,640	4,792	5,807	6,398	7,440	8,628	9,139
(3,877) Blacks (term. only)	2,409	4,143	5,066	5,587	6,545	7,550	7,745
(43,317) Nonblacks (term. only)	2,645	4,854	5,892	6,533	7,641	8,941	9,510
Nonusers by education, AFQT, and color							
ED <12							
AFQT <31							
Black (406[b])	2,174	3,725	4,568	5,088	5,921	6,794	6,486
Nonblack (2,108)	2,292	4,393	5,342	5,911	6,827	7,852	8,035
AFQT 31–46							
Black (110)	2,360	3,863	4,844	5,351	6,314	6,959	7,562
Nonblack (1,273)	2,561	4,528	5,604	6,234	6,973	8,136	8,401
AFQT 47 +							
Black (23)	2,363	3,949	4,953	5,306	6,859	7,484	6,451
Nonblack (1,019)	2,628	4,870	5,752	6,364	7,300	8,332	8,734
ED = 12							
AFQT <31							
Black (942)	2,374	4,372	5,617	6,289	7,292	8,240	8,242
Nonblack (2,485)	2,524	5,075	6,302	6,962	7,990	9,115	9,399
AFQT 31–46							
Black (391)	2,592	4,823	5,750	6,451	7,583	8,700	8,788
Nonblack (3,655)	2,700	5,329	6,485	7,213	8,258	9,340	9,711
AFQT 47 +							
Black (228)	2,859	5,279	6,467	7,230	8,568	9,648	10,034
Nonblack (10,352)	2,826	5,645	6,881	7,590	8,709	9,901	10,404
ED >12							
AFQT <31							
Black (63)	2,324	4,992	6,418	6,951	8,349	8,965	9,499
Nonblack (93)	2,382	5,133	7,015	7,463	8,677	10,085	10,371
AFQT 31–46							
Black (45)	2,483	4,650	6,055	6,463	7,108	8,419	8,408
Nonblack (241)	2,569	5,597	7,374	8,206	9,469	10,726	11,517
AFQT 47 +							
Black (39)	2,876	6,096	7,740	8,071	8,658	10,085	11,439
Nonblack (2,588)	2,769	6,144	7,891	8,781	9,994	11,464	12,399

[a] Excludes those users who were still enrolled in training as of March 1974.

[b] Number of veterans used in calculated mean earnings.

Table 6

ANNUAL EARNINGS PROFILES OF VOC-TECH USERS AND SELECTED NONUSER GROUPS BY YEAR OF TERMINATION FROM TRAINING
(In dollars)

	Voc-Tech Users				
	Year Terminated				
Earnings year	1970	1971	1972	1973	All nonusers (observed)
1970	3,197	1,903	3,369	3,674	6,531
1971	7,075	4,157	2,523	3,588	7,231
1972	7,699	7,602	4,517	4,297	8,293
1973	9,795	8,851	7,638	5,014	9,450
1974	10,195	9,119	9,014	7,727	9,878
	n = 13	n = 60	n = 43	n = 20	n = 26,067

Note: All are users who started before 1970, participated continuously, and used 19+ months of entitlement; n = the number of individuals in the sample for that subgroup.

Table 7

ANNUAL EARNINGS PROFILES OF OJT USERS BY YEAR OF TERMINATION FROM TRAINING
(In dollars)

	Year terminated			
Earnings year	1970	1971	1972	1973
1970	7,921	7,620	6,984	4,884
1971	8,974	8,703	8,385	6,122
1972	10,737	10,221	10,282	8,369
1973	12,311	11,757	12,198	10,606
1974	13,118	12,110	12,987	11,797
	n = 85	n = 421	n = 604	n = 189

Note: All are users who started before 1970, participated continuously, and used 19+ months of entitlement; n = the number of individuals in the sample for that subgroup.

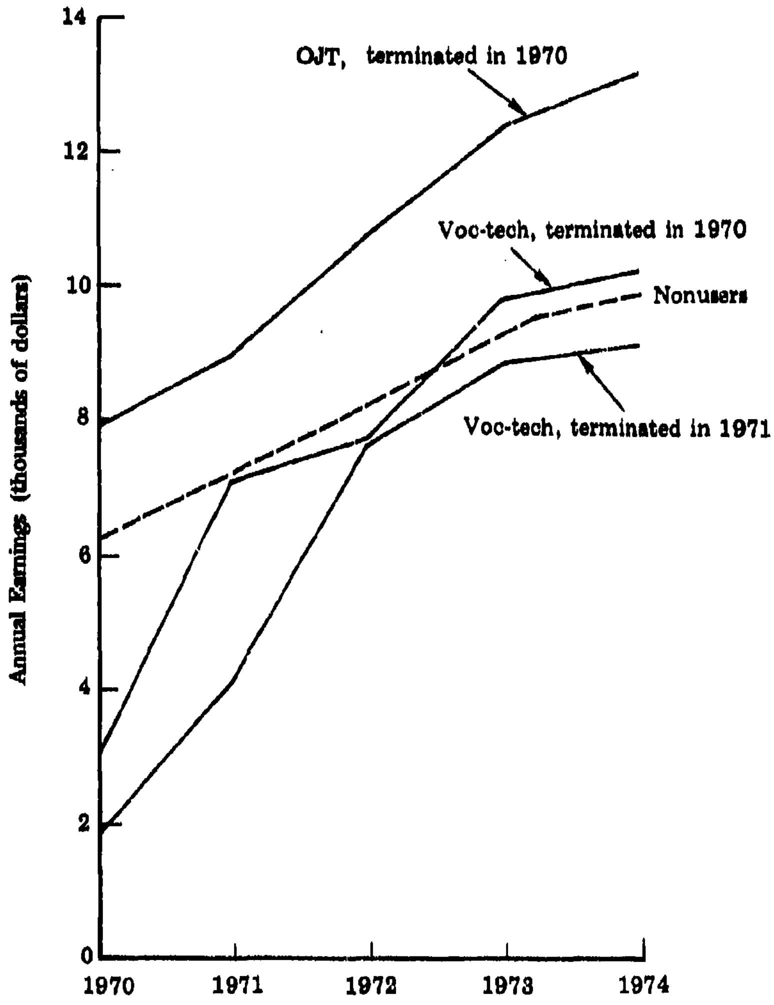

Fig. 1—Annual earnings for selected user and nonuser groups

Two patterns are evident in Fig. 1. First, the earnings profile of the selected OJT group, the one that terminated training in 1970, does not conform to the human-capital model at all—the earnings of the OJT users never lie below those of the nonusers. Part of this difference may be due to differences in personal characteristics, but, as will be seen below, a striking difference remains even when personal characteristics are taken into account. The earnings behavior of the OJT user is a puzzle.

The earnings profile of one group of voc-tech users, those who terminated training in 1970, appears to behave according to the theory. The earnings of this group lie below the earnings of nonusers until 1973, but then overtake them. However, the profiles of those who terminated training after 1970 are somewhat "discouraging." Although the earnings of these voc-tech users jump dramatically during the year after termination from training, their profiles lie below and are approximately parallel to those of the nonusers in later years.

Two problems are apparent in these earnings comparisons. For one, the personal characteristics of the different groups have not been held constant. As seen above, the voc-tech users have lower average education levels and AFQT scores than OJT users and nonusers, and a higher percentage are black. These differences in personal characteristics will bias earnings comparisons. Further, the earnings of different groups will depend upon the job opportunities available to them upon leaving active duty. We hypothesize that among the veterans who do not plan to attend college, participation in the GI Bill program and the type of training acquired are determined by the job opportunities open to them when they leave active duty. Those with the best job opportunities either do not participate in the program or use the GI Bill for OJT. Those with the worst job opportunities use it to participate in full-time voc-tech training programs; those with "intermediate" opportunities use it for part-time training.

Determination of the contribution of voc-tech training and OJT to earnings capacities requires comparison of each group of users with a control group of nonusers who have the same personal characteristics and similar job opportunities upon leaving active duty, but who, for one reason or another, did not use the GI Bill. The Social Security data contain a quarterly reporting pattern variable that indicated for each calendar quarter whether the individual earned less than $50. We used this quarterly pattern indicator to construct a measure of the job opportunities open to individuals.

To develop an adequate control group of nonusers, we regressed the yearly earnings of the nonusers on education level, AFQT score, other personal characteristics, and two variables that measure job opportunities—the number of quarters with less than $50 of earnings during the first year after separation from service, and the number of quarters with less than $50 of earnings during the second year after separation from service. Regressions were fitted to the nonuser earnings data for each of the years 1970 through 1974. To obtain estimates of yearly earnings with which to compare the voc-tech (OJT) users, we inserted the average education level, AFQT score, etc., *of the voc-tech (OJT) users* into the estimated regressions to give the predicted earnings of nonusers who have the same attributes as voc-tech (OJT) users.

Table 8 gives the estimated earnings of nonuser groups who have the same personal attributes as the voc-tech and OJT user groups, under various assumptions about the earnings patterns during the first two years after separation from the service. Two conclusions are evident from the comparisons in Table 8: The first is that if we accept the nonusers who had two quarters with less than $50 of earnings during each of the first two years after service as the adequate control group, voc-tech training is improving earning capacity. The training does appear to be benefiting those who have very poor job opportunities immediately upon leaving service, at least for those voc-tech users who terminated training in 1970 and 1971. Also, 1974 was a recession year, and it is likely that the earnings growth for the voc-tech user group would have been greater if 1974 had been a normal year. The voc-tech users had less job seniority than the nonusers and were therefore more susceptible to layoffs.

The other finding is that the earnings difference between OJT users and nonusers cannot be explained by differences in personal characteristics. OJT users still earn considerably more than similar nonusers, even those who had perfectly stable earnings patterns during their first two years after service.[7]

Our earnings analysis also attempted to determine whether voc-tech and OJT experience had a larger effect on the earning capacities of blacks or on that of nonblacks. Other factors held constant, black nonusers of the GI Bill were found in the 1974 earnings regression to have earned an average of $920 less than nonblack nonusers. The 1974 earnings of voc-tech users who terminated training before 1974 were analyzed; 1974 earnings of voc-tech users were regressed on education level, AFQT score, race, length of voc-tech training, length of time since termination from training, and other variables. The 1974 earnings of blacks were estimated to be $250 *more* than those of nonblacks, although the difference was not statistically significant. Since among the nonusers, blacks earn considerably less than nonblacks, while among the voc-tech users, blacks earn the same amount or slightly more, voc-tech training is apparently enhancing the earnings capacity of blacks more than that of nonblacks.

[7] Part of our continuing investigation is to determine why the earnings of OJT users lie uniformly above those of nonusers. Because we have no firm results to report on this question, we leave it as a puzzle.

Table 8

ACTUAL EARNINGS OF SELECTED USER GROUPS[a] AND ESTIMATED EARNINGS OF NONUSERS ADJUSTED FOR PERSONAL CHARACTERISTICS, BY ASSUMED NONUSER EMPLOYMENT STABILITY PATTERN, YEAR USER TERMINATED TRAINING, AND TYPE OF TRAINING
(In dollars)

	Employment	Nonuser Stability	Assumption	User		
	Actual Nonuser Mean			Year Training Terminated		
Year		1,1[b]	2,2	1970	1971	1972
				Voc-Tech		
1971	7,289	6,505	5,325	7,075	4,157	2,523
1972	8,057	7,362	6,366	7,699	7,602	4,517
1973	9,417	8,794	7,851	9,795	8,851	7,638
1974	9,902	9,219	8,184	10,195	9,119	9,014
				(n = 13)	(n = 60)	(n = 43)
		0,0		OJT		
1971	7,408	7,810		8,974	8,703	8,385
1972	8,503	8,854		10,737	10,221	10,282
1973	9,700	10,026		12,311	11,757	12,198
1974	10,057	10,415		13,118	12,110	12,987
				(n = 85)	(n = 421)	(n = 604)

[a]All users started before 1970, participated continuously, and used 19+ months of entitlement; n = number of individuals in the sample for that terminee subgroup.

[b]The first number is the number of quarters with less than $50 earnings in the first year; and the second, that in the second year.

The 1974 earnings of OJT users were analyzed in a similar fashion. Black OJT users were estimated to earn $650 less in 1974 than non-black OJT users. Since the 1974 racial earnings difference among nonusers was $920, OJT is improving the earnings capacity of blacks at least as much as that of nonblacks.

THE EFFECTS OF IN-SERVICE TRAINING

The goal of this section is to investigate in-service occupational training. First, what factors are related to the probability that a veteran will use his in-service occupational training when he returns to the civilian sector? Second, what contribution does in-service occupational training make to civilian earnings? There are two issues here: Does the *type* of occupational training received in the military explain any of the postservice variation in earnings (whether or not the training is used)? And, is there a positive earnings effect due to *use* of in-service occupational training in the civilian sector?

Several previous studies have looked at the extent to which skills acquired in the military are used in the civilian sector and whether use of this training enhances earnings.[8] Generally speaking, these studies find a rather low extent of use of military-acquired skills in the civilian sector,[9] and they fail to find any increase in earnings due to the use of training.[10] The hypothesis that military training makes a substantial contribution to the civilian sector human-capital stock has not received affirmation in these studies. We reexamined these questions in the light of our larger and much richer data set.

Determinants of Postservice Occupational Choice

This section briefly reports on the postservice occupational choice behavior of the nonusers of the GI Bill. The analysis focuses on the factors that are related to whether or not the veteran chooses a civilian occupation related to his military occupation. The DoD Ten Month

[8] Studies of postservice occupational choice behavior include those of Winkler and Thompson (1971), Richardson (1968), Weinstein (1969), and Giesecke (1973). Studies of the payoff to use of military training include those of Jurkowitz (1969), Massell and Nelson (1974), and Giesecke (1973).

[9] Exceptions to this rule are the studies of Winkler and Thompson (1971) and Richardson (1968). Both studies examined Air Force veterans and found that over 60 percent of the veterans trained in certain technical occupations were in related civilian occupations.

[10] Giesecke found some, although not many, military occupations in which Army veterans in related occupations were earning more than Army veterans in unrelated civilian occupations.

Survey asked each individual for a description of his civilian occupation. From these responses, the DoD (MARDAC) determined each individual's three-digit occupation category. Using a cross-classification of DoD and civilian occupation codes, we have determined whether each individual was in a highly related or somewhat related civilian occupation.[11]

The postservice occupational choice was viewed as a probability process. That is, given the individual's military occupation, preservice education level, AFQT score, etc., there is a certain probability that he will choose a civilian occupation related to his military occupation. Within this choice framework, we estimated how changes in various factors influence this probability.

To make these estimates, we applied two alternative statistical procedures to the data. The first was to regress a binary dependent variable for whether or not each individual was in a related civilian occupation on dummy variables for the various factors thought to influence this choice. Because of certain econometric difficulties that this regression procedure entails, the logit procedure was also applied.[12] In the logit procedure, the individuals are grouped into cells, the proportion (P) of individuals in related occupations in each cell is computed, and $y = \ln(P/(1-P))$ is regressed on dummies for the various explanatory (independent) variables.[13] Table 9 gives the results obtained when these alternative procedures were applied to the data.

For a given variable, the difference in the coefficients for any two levels of the variable represents the estimated difference in the probability of being in a related civilian occupation, *other factors held constant.* Thus, using the binary regression results, the probability of Air Force veterans being in a related civilian occupation, other things being equal, is .050 higher than that of Army veterans and .029 higher than that of Navy veterans.

Both regression procedures find that the most important determinant of the probability that an individual will be in a related civilian occupation is his military occupation. The other factors are seen to have much smaller influences on this probability.

Once other factors are controlled for, the probability of being in a related civilian occupation does vary somewhat by branch of service, being highest for Air Force veterans and second highest for Navy

[11] A list of related military and civilian occupations is available upon request.

[12] Kmenta (1971, pp. 425-428) provides a good discussion of regression on a binary dependent variable and problems with the procedure. The two inherent difficulties are (1) the regression may predict a probability outside the bounds of 0 and 1, and (2) the error term is heteroskedastic and therefore the parameter estimates may be inefficient.

[13] For a discussion of the theory and an empirical example of the logit procedures, see Theil (1971, pp. 632-636).

Table 9

RESPONSE OF THE PROBABILITY OF BEING IN A RELATED CIVILIAN OCCUPATION TO CHANGES IN VARIOUS FACTORS, ESTIMATES FROM TWO REGRESSION PROCEDURES[a]

Factor	Binary Regression[b]	Logit Regression
Constant[c]	-.010	.028
One-Digit Military Occupation		
Infantry (omitted)	--	--
Electronic Equip. Repair	.153(12.70)	.189(14.67)
Communications/Intelligence	.024(2.27)	.057(4.55)
Medical	.078(5.35)	.142(8.55)
Other technical	.291(15.45)	.268(14.89)
Administrative/Clerical	.193(23.86)	.216(21.99)
Electrical/Mechanical Equipment Repair	.173(21.77)	.201(20.41)
Craftsmen	.267(22.68)	.277(23.30)
Supply/Service Handlers	.114(13.94)	.161(15.46)
Race		
White (omitted)	--	--
Black	-.088(.86)	.031(2.73)
Reason for service		
Draftee (omitted)	--	--
Enlistee	-.005(.85)	.016(2.30)
Branch of service		
Army (omitted)	--	--
Navy, Marine Corps	.021(2.32)	.023(2.59)
Air Force	.050(4.30)	.041(3.49)
AFQT score		
<33 (omitted)	--	--
33-66	.006(.93)	.002(.34)
>66	.025(3.39)	.019(2.30)
Education level		
<12	--	--
12	.012(1.65)	.003(.12)
>12	.053(5.19)	.052(4.88)
Highest pay grade		
E4 and below (omitted)	--	--
E5 and above	.030(5.51)	.024(4.18)

[a] t-values are in parentheses.

[b] t-values on variables in the binary regression are only approximate, since the error term in this regression is not normally distributed.

[c] The constant is the predicted probability for individuals who fall into all the cells omitted from the regression.

veterans. The probability also rises slightly with AFQT score, education level, and highest pay grade.[14]

There are two reasons why the probability of being in a related civilian occupation should be expected to vary from one military occupation category to another. For one, varying proportions of recruits assigned to different military occupations may have gotten the training they wanted. Higher proportions of those assigned to certain occupations (e.g., Infantry) might have chosen other military occupations had they been given a free choice.[15] Proportionately more people assigned to certain other occupations may have been assigned to their "desired" occupation. Second, veterans are more likely to enter related civilian occupations if they can earn more (both now and in the future) in the related civilian occupation than in an unrelated one. The desire for a particular type of in-service training is partly dependent upon the return to that type of training in the civilian sector.

With the advent of the all-volunteer force, the military is paying more attention to recruits' preferences in determining their military occupations. In the future, the likelihood that veterans will choose related civilian occupations should be expected to rise in all military occupation categories (and it should become more similar across military occupation categories).

In-Service Occupational Training and Postservice Earnings

The analysis of the effect of military occupational training on postservice earnings followed several steps. In the first step, the yearly earnings of all nonusers were regressed on variables expected to influence earnings (education, AFQT score, etc.), including dummy variables for the individual's one-digit military occupation category and whether the individual was in a related civilian occupation. The coefficient on the dummy variables for occupational relatedness gives the *average* earnings effect due to being in a related civilian occupation.

Second, since the earnings effect due to being in a related civilian occupation may depend upon the military occupation the individual was trained in, we reestimated the overall regression described above to include interactions between one-digit military occupation category

[14] It is interesting to compare the logit and binary regression results. The results are fairly consistent on all variables except race and reasons for service. The inconsistent results have not yet been reconciled. However, even though the logit procedure does indicate statistically significant differences between blacks and nonblacks and draftees and enlistees, the differences are not very great.

[15] Fred Suffa of the Office of Manpower and Reserve Affairs pointed out after the conference that military occupational assignments were not generally made on the basis of recruit preferences in this era, but were made on the basis of test scores and educational background. Further, this held true for both enlistees and draftees.

and occupational relatedness. In this specification of the earnings regression, the earnings effect due to being in a related civilian occupation depends upon the military occupation the individual was trained in. If the payoff to using training depends upon the type of training received, there will be significant differences between military occupation categories in the earnings effect due to being in a related civilian occupation.

Table 10 reports the estimated earnings differences between military occupation categories and the earnings effect due to being in a related civilian occupation when the first procedure described above was applied to the data.

One problem in comparing the 1970 and 1974 regression is that the inflation between 1970 and 1974 tends to widen estimated earnings differences, even though *real* earnings differences are unchanged. To correct for the inflation problem, each coefficient in the 1974 regression is deflated by a GNP implicit price deflator (125.78, based on 1970 dollars) to make the 1970 and 1974 earnings differences comparable in real terms. The third column of Table 10 presents 1974 differences in 1970 dollars.

Table 10

CIVILIAN SECTOR EARNINGS DIFFERENCES ATTRIBUTABLE TO MILITARY OCCUPATION CATEGORY AND RELATEDNESS OF CIVILIAN AND MILITARY OCCUPATIONS[a]

	1970	1974	1974 (1970 Dollars)
One-Digit Military Occupation Category[b]			
Infantry (omitted)	—	—	—
Elec. Equip. Repair	385(3.50)	724(3.64)	575
Comm./Intell.	-33(.45)	205(1.20)	162
Medical	-169(1.69)	-374(1.59)	-297
Other Tech.	410(3.13)	53(.17)	42
Admin./Cler.	91(1.58)	111(.82)	88
Elec./Mec. Equip. Repair	201(3.57)	295(2.24)	234
Craftsmen	347(4.21)	617(3.19)	490
Supply/Service	96(1.68)	27(.20)	21
In a Related Civilian Occupation			
Yes	355(7.24)	303(2.63)	240

[a]t-value associated with estimated earnings difference is in parentheses.

[b]Each occupation category coefficient represents the earnings effect due to training in the occupation rather than the infantry.

First, those who were in related civilian jobs in 1970 earned, on the average, $355 more than those who were not. In 1974, the difference was $303 in 1974 dollars, or $240 in 1970 dollars. Although the earnings difference between those in related and unrelated occupations appears to diminish over time, the difference (real as well as nominal) is *widening* in some military occupations.

Second, it is evident from Table 10 that there are significant differences in postservice earnings according to the military occupational category the individual was trained in. And the real as well as nominal difference between those trained in the Infantry and those trained in certain other occupations (Electronics Equipment Repair, Communications/Intelligence, Administrative/Clerical, and Craftsmen) is increasing over time. These earnings differences appear even for individuals who are *not* in related civilian occupations. The possible reasons for the appearance of these differences even for those in unrelated occupations merit some discussion.

There are at least two possible reasons: First, different types of in-service occupational training may add different amounts to "general" human capital. That is, different types of in-service occupational training differentially improve an individual's ability to perform a wide variety of tasks in the civilian sector.

An alternative explanation is that the occupational earnings differences measure differences in ability or background that are not captured by other variables (e.g., AFQT score and educational level). This explanation implies that the occupational earnings differences are not measuring differences in the contribution of alternative types of military training to general productive skills but are measuring something else. While it cannot be "proved" which explanation is correct, we belive the former explanation is more likely.

Next, to test whether the earnings effect due to being in a related civilian occupation depends upon the military occupational category the individual is trained in, the overall earnings regression was reestimated to include interactions between occupational relatedness and occupational category. Table 11 reports the results. Coefficients on the other variables (education, etc.) were unchanged when these interactions were added to the regression.

In Table 11, the estimated earnings differences between military occupational categories are changed somewhat from the estimates in Table 10, but not dramatically. However, it is evident in Table 11 that the earnings effect due to use of military occupational training in the civilian sector varies considerably from one military occupation category to another. Those individuals trained as Electronics Equipment Repairmen who went into related civilian occupations earned $651 more in 1970 and $614 more in 1974 than individuals trained in that

Table 11

EARNINGS EFFECTS DUE TO MILITARY OCCUPATION CATEGORY AND OCCUPATIONAL RELATEDNESS[a]
(t-values in parentheses)

Military Occupation Category	1970		1974		1974 (1970 Dollars)	
	Occupation Category	Occupational Relatedness	Occupational Category	Occupational Relatedness	Occupational Category	Occupational Relatedness
Electronics Equipment Repair	320 (3.49)	651 (3.60)	607 (2.83)	773 (1.82)	482	614
Communications/ Intelligence	−28 (.37)	142 (.56)	127 (.72)	1,130 (1.89)	100	898
Medical	−208 (1.98)	610 (2.14)	−315 (1.27)	−431 (.64)	−250	−342
Other Technical	451 (2.87)	216 (.83)	141 (.38)	−22 (.03)	112	−17
Administrative/ Clerical	67 (1.10)	421 (4.44)	2 (.01)	654 (2.94)	1	519
Electrical/Mechanical Equipment Repair	181 (3.06)	410 (4.23)	272 (1.96)	282 (1.24)	216	224
Craftsmen	305 (3.25)	467 (3.00)	467 (2.13)	717 (1.96)	317	570
Supply/Service Handler	122 (2.50)	88 (.71)	90 (.64)	−387 (1.33)	71	−307

[a]Each occupation category coefficient represents the earnings effect due to being trained in the occupation rather than the infantry. Each occupational relatedness coefficient represents the earnings effect due to using training in the civilian sector in the given military occupation.

category who went into unrelated occupations after service. The earnings difference in the Electronics category between those who do ($355) and those who do not ($240) use their military training in the civilian sector is considerably larger than the 1970 and 1974 differences for all occupations combined.

Between 1970 and 1974, the real as well as nominal earnings difference between those in related and those in unrelated occupations rose for those trained as Communications/Intelligence Specialists, Administrative/Clerical Specialists, and Craftsmen. In 1974, these three occupational categories and the Electronics Equipment Repair category showed the largest earnings effect from being in a related civilian occupation. Since these are, generally speaking, the four most highly skilled military occupation categories, the finding that there are significant, positive earnings effects due to using skills acquired in these military occupations in the civilian sector is quite believable.

Consistent with these findings is the fact that except for Communications/Intelligence, these occupational categories have the highest proportion of veterans in related civilian occupations.[16] As argued previously, the decision to use military training in the civilian sector and the payoff to doing so are clearly related. Those who received training in these four highly skilled occupations and went into related civilian occupations earned between 7.1 percent and 12.5 percent more than otherwise similar individuals who received the same training but went into unrelated civilian occupations after service.

For individuals trained in the four other military occupations, the earnings difference in Table 11 between those in related and those in unrelated civilian occupations diminished between 1970 and 1974. There are three cases where those in related civilian occupations are estimated to have earned less in 1974 than those in unrelated occupations.[17]

The interrelation between the decision to use military training and the return from doing so is again evident. The Supply/Service Handlers and Medical occupations show the largest negative return to being in a related civilian occupation, and those occupations have

[16] The small percentage of Communications/Intelligence Specialists in related civilian jobs is a puzzle, as there are a significant number of related civilian occupations. These are high-skilled occupations, however, so the low percentage may reflect some occupational entry barriers in the civilian labor market.

[17] The lower earnings of those in the Medical category who went into related civilian occupations is a puzzle. These lower earnings may be explained on the grounds of taste differences (people are willing to go into these occupations even though they pay poorly) or on the grounds that individuals are still receiving substantial OJT (see Mincer, 1974).

lower percentages of veterans in related civilian occupations than do the occupations with a higher payoff.[18]

In Table 11, the earnings differences associated with use or nonuse of a given type of military occupational training in the civilian sector are, in most cases, much larger than the earnings differences associated with alternative types of training (for those who do not use training). We may infer that the value of alternative types of military occupational training depends primarily upon whether the training is used in the civilian sector. The military occupation a person is trained in is not terribly important if he does not go into a related occupation after service, but receipt of certain types of training can be very valuable if the training is used after service.

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[18] One inconsistency here is the result for Other Technical Specialists. A rather high percentage of these are in related civilian jobs, but those in related civilian occupations are not found to earn more than those in unrelated occupations. Since our sample contains only 215 people in the Other Technical category, the insignificant earnings effect here may be only a statistical aberration.

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POSTSCRIPT

By most measures, the Rand Conference on Defense Manpower would have to be judged a success. More than 150 papers were originally submitted for consideration, and these covered a broad array of subjects. The Conference was attended by more than 100 persons (in fact, attendance had to be limited to about 110 persons because of space limitations at the Rand conference facilities). These participants and attendees represented a very broad cross-section of individuals concerned about defense manpower policy, including a number of senior officials of the Defense Department (both then and now). (A list of attendees and their affiliations is given in Appendix B.) The agencies and organizations represented included the Office of the Secretary of Defense, the individual military services, other Federal agencies, inhouse defense research facilities, civilian contractors working for the Department of Defense, and universities and colleges.

I know that I—and I am sure that the other participants and attendees as well—got a great deal out of the Conference, not only from the papers presented formally, but also from the informal discussions that took place throughout the three days of the Conference. Indeed, perhaps the greatest benefit of the Conference was the interchange of information and ideas among the participants and attendees.

The significant attention given to manpower requirements, a topic long ignored by the research and personnel communities, was clearly a positive sign. This attention was reflected not only in the four papers presented in Part I of this volume, but also in other papers not published in these proceedings and in the frequent mention of requirements issues throughout the three-day period. Another key issue, the importance of manpower supply in an all-volunteer environment, was addressed in depth, as illustrated by the several papers dealing directly and indirectly with this policy problem. And other papers dealing with such specific military personnel issues as retention, performance on the job, and long-term effects of military training indicated the awakening of much-needed interest in these important areas.

For all these positive signs, however, the Conference had its discouraging aspects as well, not so much in terms of what was presented or discussed, but rather in what was not. There was a notable lack in such important areas as the reserve forces (clearly one of the most significant problems today), medical issues, compensation policy, training and education, and attrition, among others. Issues related to wartime manpower problems, especially the dynamics of moving from a peacetime to a wartime environment and back again, remained virtually unaddressed, as did some of the key issues and problems concerning military/civil relations.

In addition to these specific, substantive shortcomings, the Conference revealed several other more general problems. For example, there was little involvement by academic disciplines such as political science, psychology, and sociology. In fact, academic institutions in general were underrepresented. At a broader level of concern, discussion about ways of meaningfully integrating the various pieces of the manpower problem was also missing. As a result, there was little discussion about future manpower problems and, hence, about priorities for future manpower research.

Yet in most ways, these problems, both specific and general, are less a reflection of the shortcomings of the Conference than they are an indication of the weaknesses and problems inherent in the defense manpower research and policy communities in general. Indeed, perhaps the most disturbing problem raised during the course of the Conference concerned the relative lack of communication among the various sectors of the defense manpower community. In many ways, though, these problems should not be surprising, given the relatively recent attention that has been afforded to defense manpower policy problems. With the exception of the draft debate which surfaced in the 1960s (and which served to bring many individuals into the defense manpower community), defense manpower has really been perceived as a major policy problem only since the early 1970s.

Thus, part of the problem is clearly that defense manpower is a new field, and it has been experiencing the growing pains associated with that newness. In fact, there has been significant progress in understanding the defense manpower problem during the two years since the Conference was held. The beginnings of improved coordination among reseachers and policymakers are evident, and both groups have begun to focus on establishing research priorities.

In conclusion, although there were some problems, the Conference proved to be a valuable experience. It clearly served its principal purpose: namely, to bring together a group of reseachers and policy-makers to discuss important defense manpower policy problems. The papers themselves highlighted some key policy problems and pointed toward some potential solutions. Moreover, the fact that the problems discussed above were raised must really be viewed as a positive sign, since it points to ways of improving the defense manpower community. More certainly needs to be done, and conferences of this sort can prove a valuable tool both for highlighting problem areas and for suggesting possible courses of action.

Appendix A

CONFERENCE AGENDA

CONFERENCE PROGRAM*

February 4, Wednesday

9:00 – 9:30 WELCOME

Dr. Richard V. L. Cooper, Conference Chairman
The Rand Corporation

Dr. Robert Young, Director
Human Resources Research Office
Defense Advanced Research Projects Agency

9:30 – 12:00 SESSION I
MANPOWER PROCUREMENT

12:00 – 1:30 LUNCHEON

KEYNOTE ADDRESS

The Honorable William K. Brehm
Assistant Secretary of Defense
(Manpower and Reserve Affairs)

2:00 – 5:00 SESSION II
MANPOWER TRAINING

*Although the Conference agenda proceeded as shown, it was felt that the Proceedings volume would be more appropriately organized as shown on the Table of Contents (pp. vii-viii).

February 5, Thursday

8:30 – 12:00	SESSION III MANPOWER MANAGEMENT
12:00 – 1:30	LUNCHEON
1:30 – 5:00	SESSION IV MANPOWER REQUIREMENTS

February 6, Friday

9:00 – 11:30	SESSION V MANPOWER AND SOCIAL POLICY
11:30 – 12:00	CONCLUDING REMARKS
12:00	ADJOURN

PROGRAM AND PAPERS

SESSION I
MANPOWER PROCUREMENT

Chairman:
Brigadier General Phillip Kaplan
United States Army

Discussant:
Dr. Bernard Rostker
The Rand Corporation

The Supply of Enlisted Volunteers in the Post-Draft Environment, Mr. Alan Fechter (General Research Corporation), Dr. David Grissmer (General Research Corporation)*

Enlisted First-Term Attrition Analyses, Mr. Robert F. Lockman (Center for Naval Analyses), Mr. Christopher Jehn (Center for Naval Analyses), Mr. William F. Shughart, III (Texas A&M)**

A Simultaneous Paid Radio Test in Support of Military Recruiting: Experimental Design and Test Results, Dr. Albert Martin (Office, Assistant Secretary of Defense, Manpower and Reserve Affairs), Mr. Charles Overholzer (Haley, Overholzer and Associates), Mr. Daniel F. Huck (General Research Corporation)

International Comparisons in Manpower Supply, Dr. Glenn Withers (Institute of Advanced Studies, The Australian National University)

*Originally presented as one paper, the Fechter and Grissmer papers are presented in this Proceedings volume as two papers.

**Originally presented as one paper, the (1) Lockman and (2) Jehn and Shughart papers are presented in this Proceedings volume as two papers.

SESSION II
MANPOWER TRAINING

Chairman:
Dr. Howard McFann
Human Resources Research Organization

Discussant:
Dr. Wallace Sinaikc
Office of Naval Research

A Longitudinal Assessment of Organizational Effectiveness, Mr. William E. Alley (Air Force Human Resources Laboratory, Lackland Air Force Base, Texas)

Measuring On-The-Job Performance of First-Term Enlisted Personnel, Dr. Robert M. Gay (The Rand Corporation), Mr. Mark J. Albrecht (The Rand Corporation)

The Optimal Timing and Amount of Training by the Military, Dr. Daniel S. Hamermesh (Michigan State University)

The Impact of Advanced Instructional Technology on Qualitative and Quantitative Military Manpower Requirements, Dr. Marty R. Rockway (Air Force Human Relations Laboratory, Lowry Air Force Base, Colorado)

Job Proficiency: Performance Tests and Attractive Alternatives, Dr. Robert Vineberg (Human Resources Research Organization), Dr. Elaine N. Taylor (Human Resources Research Organization)

SESSION III
MANPOWER MANAGEMENT

Chairman:
Dr. John P. White
The Rand Corporation

Discussant:
Mr. Richard Kuzmack
Defense Manpower Commission

Applications of Occupational Survey Data to Personnel Management, Dr. Raymond E. Christal (Air Force Human Relations Laboratory, Brooks Air Force Base, Texas)

The Army's Aggregate Personnel Management Information System (ELIM-COMPLIP), Major W. A. Curtis (Department of the Army)

Techniques for Increasing Retention of Enlisted Personnel, Dr. Gloria L. Grace (System Development Corporation)

The Closed System Transition of Manpower Planning, Mr. Michael P. Letsky (Office, Chief of Naval Operations)

A Dynamic Model for Optimal Bonus Management, Dr. Patricia Munch (The Rand Corporation)

Air Force Academy Graduate Retention and Performance: A Ten Year Predictive Study, Major Michael J. O'Connell (U.S. Air Force Academy)

SESSION IV
MANPOWER REQUIREMENTS

Chairman:
Mr. John Ruml
Office of the Assistant Secretary of Defense
(Program Analysis and Evaluation)

Discussant:
Dr. Charles Robert Roll, Jr.
The Rand Corporation

Capital/Labor Ratios in a Military Service -- A Putty/Clay Application, Commander Rolf Clark (Operations Study Group, U.S. Navy and the University of Massachusetts)

Maintenance Personnel Effectiveness Study, Mr. Stanley Horowitz (Center for Naval Analyses), Lieutenant Commander Allan Sherman (Center for Naval Analyses)

Optimal Composition of the DOD Military/Civilian Labor Force, Mr. Thomas P. Hasbrouck (Department of the Air Force)

A Dynamic Model for Planning Manpower Requirements, Dr. David Jaquette (The Rand Corporation)

The Peacetime Demand for Military Manpower, Dr. John F. O'Connell (College of the Holy Cross)

Economic Cost as a Military Essentiality Criterion, Captain Roy E. Smoker (Department of the Air Force)

SESSION V
MANPOWER AND SOCIAL POLICY

Chairman:
Dr. Austin Kibler

Discussant:
Professor Vincent Davis
University of Kentucky

Military Manpower Policy and Social Structure: Selected Issues, Dr. James E. Katz (Rutgers University)

The Impact of Military Experience on Post-Service Earnings Without the Draft, Dr. Charles B. Knapp (University of Texas at Austin)

The Effect of Military Training and GI Bill Training on Civilian Earnings: Evidence from the Post-Service Experience of Vietnam Era Veterans, Dr. Dave M. O'Neill (Center for Naval Analyses), Dr. Sue Goetz Ross (Center for Naval Analyses)

Utilization of Enlisted Women in the Military, Mrs. Patricia J. Thomas (Navy Personnel Research and Development Center, San Diego, California)

Appendix B

ATTENDEES TO THE RAND CONFERENCE ON DEFENSE MANPOWER*

Mr. Mark J. Albrecht
The Rand Corporation

Mr. William Albright
The Rand Corporation

Mr. William E. Alley
Air Force Human Resources Laboratory

Lieutenant Colonel Shirley J. Bach
The Brookings Institution

Lieutenant Commander Stephen J. Balut
Center for Naval Analyses

Mr. Chauncey Bell
The Rand Corporation

Colonel Donald D. Binford
Headquarters USAFRS/CV

Mr. Robert E. Boynton
Naval Postgraduate School

*The affiliations given in this appendix are those that were current at the time of the Conference. They do not necessarily reflect the situation at the time of publication of this volume.

The Honorable William K. Brehm
Assistant Secretary of Defense
(Manpower and Reserve Affairs)
Department of Defense

Dr. L. A. Broedling
Navy Personnel Research and Development
Center

Dr. Ralph R. Canter
U.S. Army Research Institute of the
Behavioral and Social Sciences

Dr. David S.C. Chu
The Rand Corporation

Commander Rolf Clark, USN
University of Massachusetts

Dr. Richard V. L. Cooper (Conference Chairman)
The Rand Corporation

Major W. A. Curtis
U.S. Army Research Institute of the
Behavioral and Social Sciences

Professor Vincent Davis
The University of Kentucky

Dr. Emerson Emory
Dallas, Texas

Mr. Alan Fechter
General Research Corporation

Mrs. Jeanne Fites
Manpower Research and Data Center,
Department of Defense

Mr. Eli Flyer
Manpower Research and Data Center,
Department of Defense

Mr. Craig Foch
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