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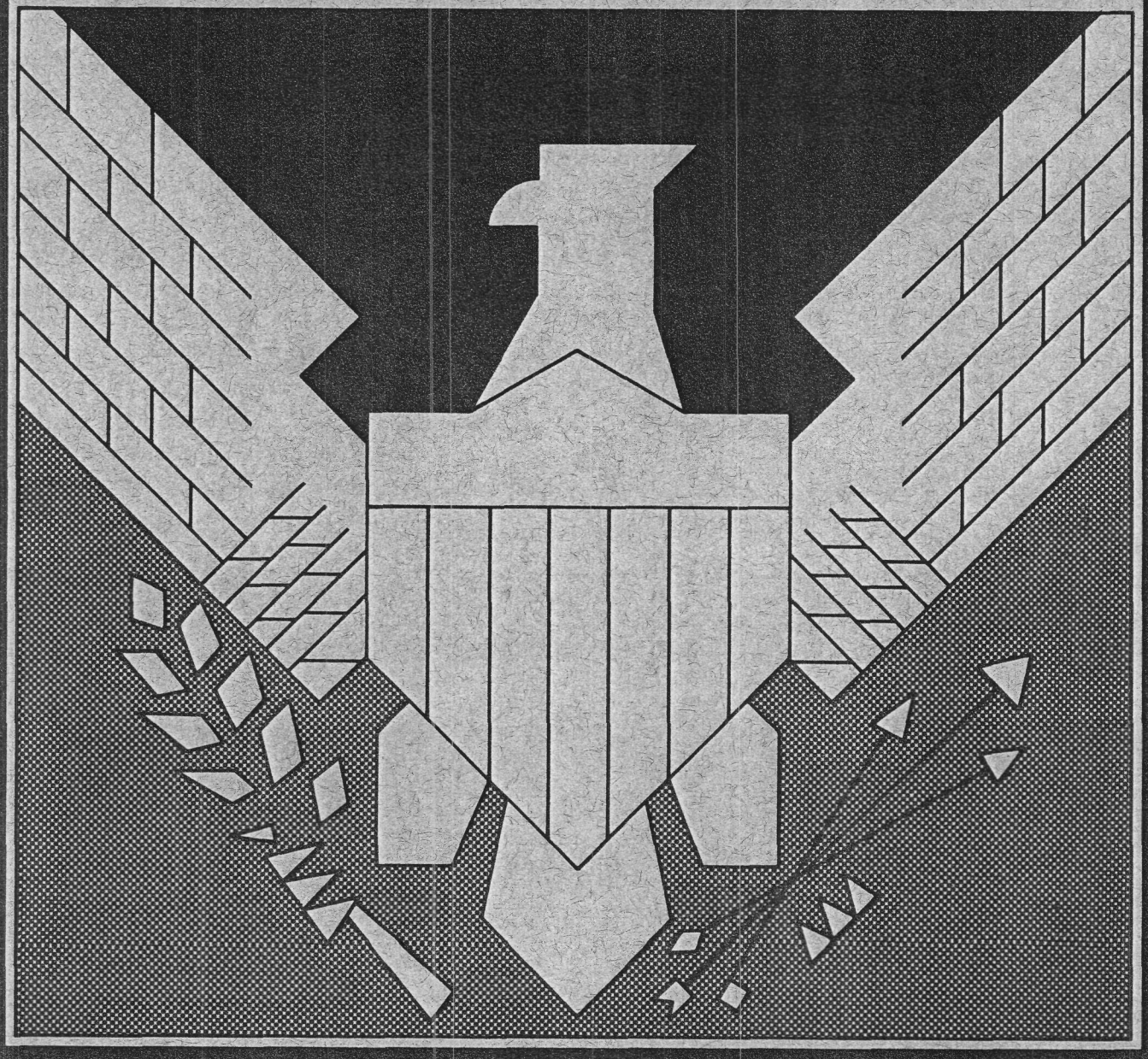
Setting Personnel Strength Levels: Experience and Productivity in the Military



CBO STUDY

SETTING PERSONNEL STRENGTH LEVELS:

EXPERIENCE AND PRODUCTIVITY IN THE MILITARY

The Congress of the United States
Congressional Budget Office

NOTES

All years referred to in this report are fiscal years unless otherwise indicated.

Details in the text and tables of this report may not add to totals because of rounding.

PREFACE

The period since military conscription was ended in 1973 has been marked by a gradual shift toward greater seniority in the active enlisted forces. This shift is likely to continue into the 1990s, with large increases in the numbers of senior career personnel adding significantly to personnel costs and perhaps increasing productivity. This report, produced at the request of the Subcommittee on Military Personnel and Compensation, House Armed Services Committee, projects the future levels of experience in the enlisted forces and examines the cost and benefits of seniority growth. It also develops alternatives to the services' enlisted strength plans that reflect increased productivity. In accordance with the mandate of the Congressional Budget Office (CBO) to provide objective analyses, the report makes no recommendations.

Richard L. Fernandez of CBO's National Security Division prepared the report under the general supervision of Robert F. Hale and Neil M. Singer. Elizabeth Sterman, also of the National Security Division, prepared much of the data. The author thanks Stanley A. Horowitz of the Institute for Defense Analysis for his insightful review of an earlier draft. (External reviewers bear no responsibility for the final product, which rests solely with CBO.) Thanks go also to the Policy and Systems Integration Office, Directorate of Manpower and Organization, Headquarters United States Air Force, which provided unplublished data from an earlier study sponsored by the Air Force. CBO staff members Elizabeth Chambers, Paul Christy, and Michael A. Miller provided helpful comments. Francis S. Pierce edited the manuscript, assisted by Nancy H. Brooks, and Rebecca J. Kees prepared it for publication.

Edward M. Gramlich
Acting Director

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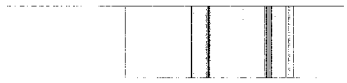


SUMMARY

Since the end of the draft in 1973, there has been a trend toward more senior enlisted forces. This trend, resulting from the higher reenlistment rates of true volunteers as compared with draftees and draft-motivated volunteers, has important consequences for personnel costs. The Congressional Budget Office (CBO) projects that seniority growth--that is, the increase in average years of service of enlisted personnel--in the four active services will raise real personnel costs in the early 1990s substantially above their 1987 levels. Over the five years 1988 to 1992, added costs will total at least $1.4 billion, and perhaps as much as $2.8 billion; in 1992 alone, costs will be higher by as much as $720 million.

These projected cost increases, amounting to 0.8 percent to 1.4 percent of total enlisted personnel costs in 1992, are an obvious target for efforts to reduce Defense Department personnel expenditures. Seniority growth thus raises two important questions:

- Will more senior forces offer benefits in terms of greater capabilities that will balance their greater costs?
- How would increased capabilities affect the appropriate sizes of the enlisted forces?

This study provides preliminary answers to these two questions, as well as projecting the coming changes in enlisted seniority and in personnel costs. Available evidence on experience/productivity trade-offs in the military indicates that, as seniority increases through the early 1990s, all four enlisted forces will become considerably more capable. This may be a fairly inexpensive way to improve defense capabilities. Seniority growth also means that cuts in enlisted strengths below planned levels could perhaps be made without reducing planned capabilities.

THE UPWARD TREND IN ENLISTED EXPERIENCE

In 1974, 28 percent of the draft-era volunteers completing their first enlistment terms chose to reenlist. Four years later, the first-term reenlistment rate was up to 36 percent. As a result of this improved retention, the

percentage of personnel in years-of-service five through ten rose substantially between 1974 and 1980 in every service--in the Army, for example, from 15.4 percent to 24.0 percent. The percentage continued to rise in the 1980s, spurred by improved military pay, high civilian unemployment, and, perhaps, more favorable attitudes toward military service.

In the late 1980s and early 1990s, the large numbers of personnel currently in years-of-service five through ten should be reflected in the senior career forces. In the Air Force, for example, the proportion of the enlisted force with more than 10 years of service should rise from 28 percent in 1985 to 33 percent in 1994. The Army and Navy should experience similar gains, and the Marine Corps an even larger increase. In the latter service, this growth will come implicitly at the expense of the first-term force; in the other services, the percentage of personnel in years-of-service five through ten will drop. These projections assume that the services will not alter their reenlistment policies, that military pay will keep pace with pay in the private sector, and that the civilian unemployment rate will continue its decline through the early 1990s.

COSTS OF SENIORITY GROWTH

Seniority growth accounts for more than one-fourth of the $2.6 billion increase in real (inflation-adjusted) annual personnel costs that this study projects between 1987 and 1992 (see Summary Table 1). Seniority-growth costs are reflected in the Administration's budget request, although Administration estimates may differ from those of this study. No seniority growth is assumed in CBO's baseline projections of the federal budget, which are used by the Congress in the budget process.

Two factors contribute to the $720 million projected cost of seniority growth: a rise in the average enlisted pay grade; and higher average pay levels because of longevity increases in basic pay.

How Seniority Growth Affects the Mix of Pay Grades

Unless promotion rates are reduced or promotions slowed, rising seniority will increase the percentages of personnel in the top four of the services' nine enlisted pay grades. In the Navy, for example, this study projects an increase for pay grades E-7 and above from 9.5 percent in 1985 to 11.5 percent in 1992; in the Army, from 10.7 percent to 12.6 percent. The shifts in grade distributions will add $300 million to personnel costs in 1992, rela-

tive to what costs would be if the aggregate mix of pay grades in each service did not change. The projected shifts continue at least into the mid-1990s, contributing to additional cost growth in those years.

The cost increases could be limited by slowing promotions, particularly to grades E-6 and E-7. If promotion times were delayed from 6 months to 21 months (depending on the service), the services' grade mixes would remain constant. Slowed promotion would adversely affect retention to some extent, an effect that this study did not explicitly consider.

How Seniority Growth Affects Pay Rates

Even without richer grade mixes, seniority growth should increase personnel costs because longevity increases are a feature of the military basic pay

SUMMARY TABLE 1. SOURCES OF GROWTH IN PERSONNEL COSTS OVER 1987 LEVELS
(In millions of 1987 dollars)

Source of Growth	1992	Total 1988-1992
Richer Grade Mix	300	890
Longevity Pay Increases	420	1,410
Personnel Strength Changes	660	1,830
Real Pay Changes	2,240	4,290
Changes in Retired Pay Accrual Rate a/	-970	-3,110
Total	2,640	5,310

SOURCE: Congressional Budget Office.

a. Effects of changes in the normal cost percentage used in calculating the accrual charge for retired pay. Does not include effects of changes in real levels of basic pay.

table. Longevity increases reward length of service independently of the effects of promotion. Other cost elements--medical costs, for example--also will show growth as the enlisted forces become more senior. When the grade mix is held constant, seniority growth contributes $420 million to personnel costs in 1992, and more in succeeding years.

EXPERIENCE AND PRODUCTIVITY

Two attempts to measure productivity at various levels of experience have yielded useful information. The Enlisted Utilization Survey (EUS), conducted by the RAND Corporation in the mid-1970s, examined productivity growth during the first enlistment term. Subsequent analyses of the data found strong relationships between experience and productivity in a broad cross-section of military occupational specialties. The second study, which looked at one Air Force specialty, found substantial growth beyond the first term.

Productivity Indexes

Averaging across occupational specialties in the EUS yields plausible indexes of productivity by year of service over the first four years of service for the Army, Navy, and Air Force. Each shows very low productivity in the first year of service, reflecting time devoted to training when productivity is assumed to be zero. The Marine Corps was not covered in the EUS; the present study has used the Army index in examining Marine Corps productivity.

Because the results of the Air Force study were sensitive to the assumptions embodied in this analysis, the present study employs three alternative indexes to span the range of likely productivity growth. Case 1, which is consistent with the assumptions of the original analysis, shows senior personnel as roughly 52 percent more productive than those with four years of service completed. Case 2 simply halves the improvement over the fourth-year reference point. Case 3 arbitrarily imposes the assumption that productivity does not improve beyond the first term. These three indexes of productivity by year of service were assumed to apply equally well to all four services, and thus were linked to the first-term indexes developed from the EUS.

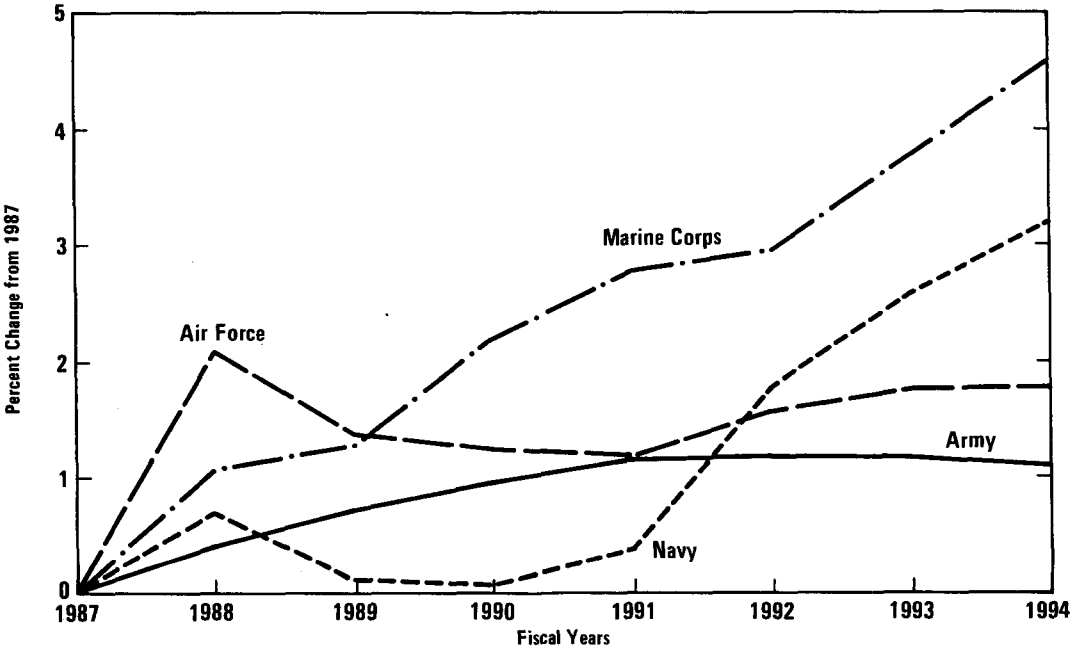
Projections of Aggregate Productivity

Applying the productivity indexes to the projections of experience structures yields significant increases in aggregate productivity in all four services through the mid-1990s. The Summary Figure shows the percentage changes, relative to 1987, in average productivity (total productivity divided by total strength) under Case 1. In 1992, the gains range from 1.2 percent for the Army to 2.9 percent for the Marine Corps. Productivity for the Navy, in particular, is projected to continue growing beyond 1992, as the depressing effect of high numbers of new recruits diminishes with the completion of the Navy's planned strength increase in 1991.

Projected productivity gains are smaller under Case 2, generally about two-thirds as large as under Case 1. These gains probably represent a conservative lower bound on the true improvement that can be expected. The Case 3 gains average about half as large as those of Case 2, but it seems unrealistic to assume that experience beyond the first term adds nothing to productivity.

Summary Figure.

Projected Changes in Average Productivity (Case 1)



SOURCE: Congressional Budget Office.

NOTE: Average productivity projections were made by multiplying projected personnel strengths in each year of service by the corresponding value of the (Case 1) productivity index, summing the result, and dividing by total personnel strength.

Based on these results, allowing the projected seniority growth to occur would appear to be a less expensive means of achieving modest improvements in defense capability than, for example, increasing enlisted personnel strengths. Conversely, the gains in productivity might allow strength reductions relative to planned levels.

ALTERNATIVES FOR ENLISTED STRENGTH LEVELS

The Navy plans to increase enlisted strength by 5.3 percent between 1987 and 1992. If experience can substitute for numbers, the seniority growth projected here could raise Navy enlisted capabilities by 5.3 percent with a much smaller increase in strength. The Army, in contrast, plans no change in enlisted strength. It, too, will experience seniority growth, however, suggesting that the capabilities of the Army's 1987 enlisted forces could be maintained with smaller numbers of personnel. This study presents alternative enlisted strength levels for all the services, giving each service a profile of future aggregate productivity matching its profile of planned future strengths.

This approach assumes that the services have not already factored productivity growth into their personnel plans. In fact, planned personnel growth has been reduced in recent years, perhaps in part because of growth in seniority and productivity. Despite substantial seniority growth, however, service manpower reports contain no specific examples of large numbers of jobs being done by fewer, more senior personnel, which suggests that growth in seniority and productivity has not been fully considered.

Using the conservative productivity estimates of Case 2, this study finds that 35,000 fewer personnel would be required in 1992 than the Department of Defense plans (see Summary Table 2). Cost savings would amount to $760 million in 1992, and over the five years 1988 to 1992 would total $2.2 billion. In all services but the Navy, the cuts would reduce personnel strengths in 1992 below 1987 levels.

Under Case 1, which assumes full productivity growth consistent with the underlying studies, personnel reductions in 1992 relative to planned levels would amount to 52,000. Five-year cost savings would total $3.6 billion, with a drop of $1.1 billion in 1992 alone. Even the extreme assumption of Case 3--no growth in productivity after the first term--would result in a personnel reduction of 18,000 relative to levels planned for 1992.

LIMITATIONS AND CONCLUSIONS

Several factors place important limits on the usefulness of this productivity analysis and make it difficult to draw firm conclusions as to possible changes in enlisted strengths. The data underlying the indexes, the only information available, are very skimpy beyond the first term, somewhat out of date, and not entirely appropriate for application to an entire service. In addition, the services' manpower systems may not have the flexibility to take full and prompt advantage of the productivity improvements that come with greater average experience. Moreover, it is possible that some of the productivity improvements have already been taken account of in the services' plans. Clearly, more research on these issues is needed.

The reductions in personnel strength discussed in this paper should not be taken as recommendations for specific action. Until the needed research is completed, the alternatives above should be interpreted instead as indications of the general magnitudes of reductions that might be warranted. In the meantime, a conservative approach to policy changes seems appropriate.

SUMMARY TABLE 2. ENLISTED STRENGTHS AND COSTS UNDER DEFENSE DEPARTMENT PLAN AND CHANGES UNDER CBO ALTERNATIVES

	Strength in 1992 (Thousands)	Costs (In billions of 1987 dollars)	
		1992	Total 1988-1992
Defense Department Plan	1,871	52.2	252.9
Reductions under:			
Case 1	52	1.1	3.6
Case 2	35	0.8	2.2
Case 3	18	0.4	1.0

SOURCE: Congressional Budget Office.

A conservative approach does not mean that the effects of seniority growth should be ignored entirely. The services have apparently decided to accept increases in seniority that will add as much as $720 million per year to their personnel costs by 1992, and they must have judged that the benefits of seniority growth are worth the cost. It seems reasonable to use the information contained in this analysis to review their decisions, especially considering the stringent limits that have been placed on defense spending as part of efforts to reduce the federal budget deficit.

CHAPTER I

INTRODUCTION

More than two million men and women serve today in America's active military forces. Roughly one-third of the Department of Defense budget is spent directly on these personnel: on recruiting, training, and transporting them; on providing for their housing, food, and medical care; and on paying them today and in their retirement. With military personnel costs absorbing so large a portion of the defense budget, and in light of continued interest in reducing the size of the federal budget deficit, considerable attention has naturally been focused on ways to reduce these expenditures.

Personnel costs in the 1980s and 1990s have been strongly influenced by the ending of military conscription in 1973. 1/ The introduction of the All-Volunteer Force (AVF) increased personnel costs in two important ways. First, the need to induce sufficient numbers of young men and women to volunteer for military service led to a substantial increase in basic pay and related costs: in preparation for the draft's end, the Congress in 1971 nearly doubled the pay of entering recruits. 2/ The second effect--less obvious because it would not be seen immediately--was a gradual increase in various cost elements, including pay, as first-term personnel were replaced by more senior service members.

The shift toward more senior enlisted forces was a consequence of the reliance on volunteers to meet the military's need for new recruits. As first-term personnel became more expensive, economy dictated a greater reliance on trained, experienced personnel. The shift occurred naturally because the recruits who entered the AVF, without any direct or indirect pressure from a draft, were more inclined than their predecessors to reenlist after completing their initial tours.

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1. Authority for the draft ended on July 1, 1973. The last draft calls were issued in December 1972.

2. The raise in basic pay, over a typical recruit's first two years, amounted to 85 percent. More senior personnel received much smaller raises. Scheduled to take place in October 1971, the raise was delayed until November 14 by President Nixon's wage-price freeze. An additional across-the-board increase of 7.2 percent was given on January 1, 1972.

Because military careers span 20 or more years, the transition to a mature AVF is still under way. The enlisted forces of the 1990s will look quite different from those of the 1980s, in that much higher percentages of them will have more than 10 years of service. Personnel costs will be higher because more service members will be married, because military families will be larger on average, and, most important, because automatic pay increases for longevity will ensure a rise in average pay levels, even apart from the cumulative effect of annual across-the-board pay raises.

The coming changes in the experience structures of the enlisted forces raise some important questions, among them:

- What will be the extent of the changes?
- How much will they cost?
- To what extent will the coming changes increase the capabilities of the enlisted forces?
- How will increases in force capabilities affect the numbers of personnel needed in the four active services?

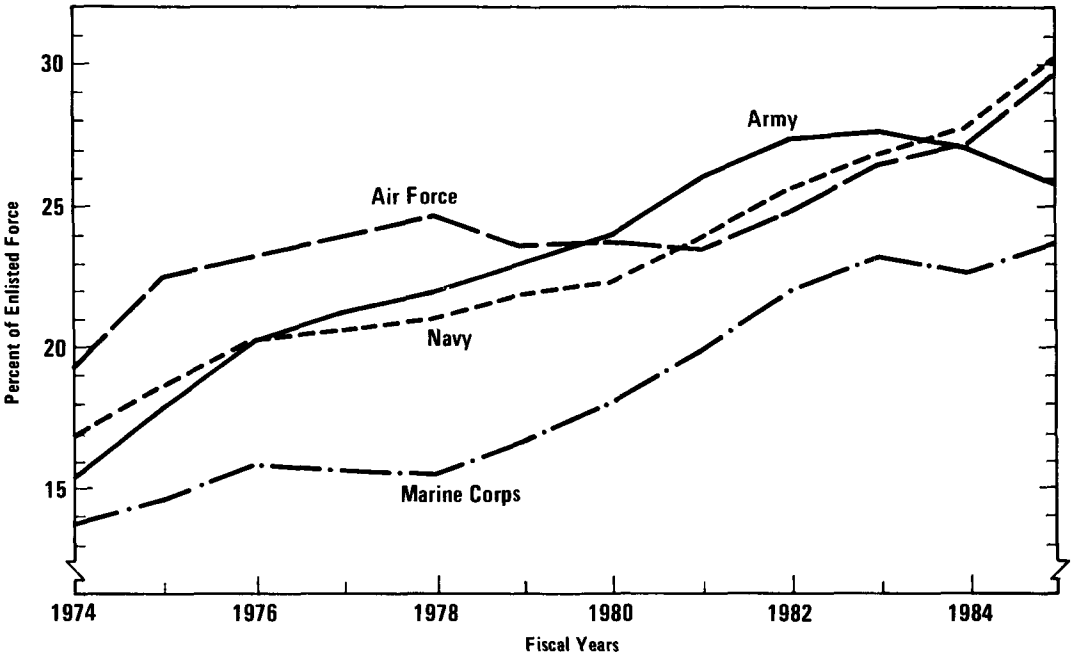
This paper attempts to answer these four questions. Chapter II presents projections of the experience structure of the enlisted force in each of the four active services and gives estimates of the cost increases that will result from the continuing maturation of the AVF. Chapter III tackles the more difficult third question: it examines the relationship between experience and productivity, using what data are available to derive indexes of productivity by year of service, and applies the indexes to the projections of Chapter II. The final chapter examines alternatives to the services' personnel plans that would exploit the projected seniority growth by substituting experience for numbers without sacrificing planned levels of capability.

The remainder of this chapter sets the stage for what follows by showing the changes in enlisted experience structures that have taken place since the start of the AVF and giving a preliminary answer to the question: Is more experience desirable?

BACKGROUND

The draft-era volunteers (not draftees) who completed their first terms in fiscal year 1974 reenlisted at a rate of 28 percent across the four services (excluding ineligibles). Four years later, the first-term reenlistment rate

Figure 1.
Junior Noncommissioned Officers As Percent of Enlisted Force, 1974-1985



SOURCE: Congressional Budget Office, based on Department of Defense manpower statistics.
NOTE: Junior personnel are those in years-of-service five through ten.

was up to 36 percent. 3/ Figure 1 shows the major effect of this improved first-term retention. In 1974, junior noncommissioned officers--consisting for purposes of this study of those in years-of-service five through ten--accounted for 15.4 percent of the Army's enlisted force. By 1980, that figure had risen to 24.0 percent. Similar changes, though less extreme, took place in the other services during the 1970s. Although comparisons with 1974 are colored to some extent by the effects of post-Vietnam force reductions, the upward trend persisted into the late 1970s in all the services but the Air Force.

In its 1970 report, the President's Commission on an All-Volunteer Armed Force, better known as the Gates Commission, foresaw the change toward more senior enlisted forces: "The higher retention rate for true volunteers inevitably produces a more experienced force. Our projections

3. Department of Defense, Washington Headquarters Services, Directorate for Information, Operation, and Reports, *Selected Manpower Statistics Fiscal Year 1981*.

indicate that, by 1980, 45 percent of Army enlisted men will have four years or more of service experience, as compared with 31 percent for a mixed force [volunteers and draftees] of the same size." 4/ The actual percentage was closer to 50.

The Gates Commission could not foresee the events of the early 1980s. Two large military pay raises, high unemployment rates, and, perhaps, more favorable attitudes toward military service boosted the first-term reenlistment rate to nearly 50 percent in fiscal year 1983. The effect is apparent in Figure 1: the Army's junior noncommissioned-officer force rose to almost 28 percent of the total in 1983, while in the other services growth continued through 1985.

Is a more experienced force desirable? The Gates Commission thought so, noting that: "Since experience involves on-the-job training, a more experienced force is more productive than a less experienced one." 5/ The commission also pointed out that lower overall turnover, which is associated with a more senior force, reduces the number of personnel in training and other forms of "noneffective" status. Ten years later, the Defense Resource Management Study concluded that: "For many enlisted personnel occupational groups, a force with more careerists and fewer first-termers would be cost-effective based on current organizational structures." 6/

Evidence that productivity grows with experience is provided by the obvious increase in earnings with age. Economic theory indicates that wages reflect a worker's marginal contribution to output, net of the value of any on-the-job training the worker is receiving. One study found that high school graduates aged 35 to 44 earned 68 percent more than those aged 22 to 24. 7/ A similar rise is evident in military pay tables: an enlistee with two years of service (in grade E-3) receives less than half as much in basic pay as one with 20 years of service (E-7). Although the connection between pay and marginal productivity is easier to show for the private sector than for the military, where occupational pay differences are small, the structure of military pay tables certainly creates a presumption that the services value experienced personnel more highly than junior personnel.

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4. *The Report of the President's Commission on an All-Volunteer Armed Force* (New York: Collier Books/The Macmillan Company, 1970), p. 40.

5. Ibid., p. 41.

6. Donald B. Rice, *Defense Resource Management Study: Final Report* (Washington, D.C.: Government Printing Office, February 1979), p. 64.

7. Gary S. Becker, *Human Capital* (New York: Columbia University Press, 1964), p. 138.

CHAPTER II

PROJECTED EXPERIENCE STRUCTURES, AND COSTS, FOR THE ENLISTED FORCES

The growth in the proportion of junior noncommissioned officers (NCOs) in the active services since the start of the All-Volunteer Force has set the stage for substantial growth in the senior career forces during the late 1980s and early 1990s. This chapter begins by showing projections of the extent of that growth under current policies. A number of assumptions that underlie the projections are detailed in the second section. Personnel costs will rise significantly over the period of the projections, as shown in the third section. The final section shows how much of the cost increases are attributable to seniority growth. It breaks the increases down into two components, one resulting from higher average pay grades and the other from longevity increases in basic pay.

PROJECTED EXPERIENCE STRUCTURES

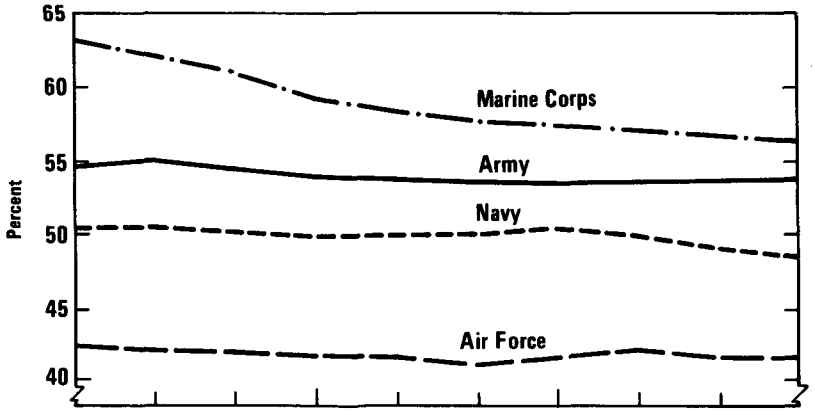
CBO's projections show sharply rising percentages of senior NCOs--enlistees with more than 10 years of service--through the mid-1990s (see Figure 2). 1/ This group should account for 33 percent of Air Force enlisted personnel in 1992, for example, compared with approximately 28 percent in 1985. The Navy and Army should show similar growth--smaller in terms of percentage points but larger relative to their starting positions of roughly 20 percent in 1985. The largest increase should occur in the Marine Corps: from 13.4 percent of the force to 19.6 percent. Given the modest growth in personnel strength planned for the Marine Corps, the rise implies a 50 percent increase in the number of senior NCOs.

For the most part, the projected growth in the senior NCO forces comes implicitly at the expense of the group in years-of-service five

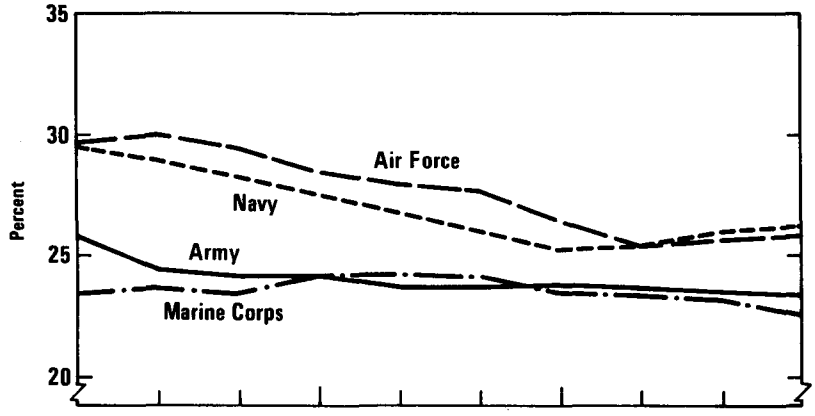
1. Figure 2 divides enlisted personnel into three groups: first-termers, approximated by those in years-of-service 1 through 4; junior NCOs (YOS 5-10); and senior NCOs (YOS 11 and above). The standard active duty service obligation for new recruits in the Navy, Air Force, and Marine Corps is four years. For consistency across the services, the figure treats four years as the first term. The majority of Army recruits, however, choose two- or three-year obligations. Some Marine Corps recruits also are eligible for three-year obligations, and Navy reservists going on extended active duty enter for two or three years.

Figure 2.
Projected Distribution of Active Enlisted Personnel, by Years of Service, 1985-1994

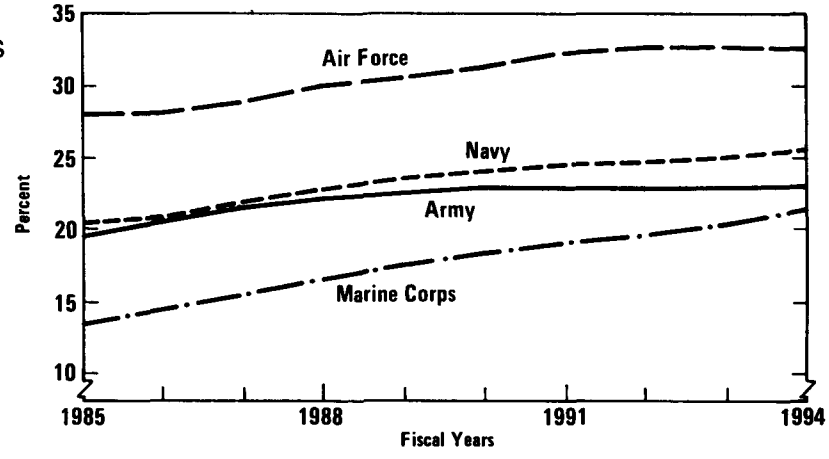
One to Four Years of Service



Five to Ten Years of Service



Eleven or More Years of Service



SOURCE: Congressional Budget Office.

through ten. The Navy and Air Force, for example, show four percentage-point drops for this group, and less than one-half point drops for first-termers. In the Army the reduction is a little more evenly split between the two groups, but more than half comes from the junior NCO group. Only in the Marine Corps, the smallest service, is the shift predominantly from the first-term to the senior NCO force.

PROJECTION ASSUMPTIONS

This study derived its projections from the services' 1985 year-end experience profiles--the latest detailed data available. These were appropriately aged, and adjusted for a mixture of demand and supply effects. The key demand-side factors are the services' reenlistment policies. Year-to-year changes in force sizes also play a role, although more in determining costs (below) than in affecting experience profiles. On the supply side, service members' propensities to remain in the military have been shown to be influenced by military pay levels and the availability of private-sector jobs. This section discusses the demand and supply factors in turn, and then identifies the study's major economic assumptions.

Demand-side Factors

The projections of experience profiles shown above, as well as those discussed in Chapter 4, assume that, in the absence of any change in members' propensity to remain in the military, retention rates would remain constant at their 1985 levels. This is roughly equivalent to assuming that the services will not change their policies for determining who is eligible to reenlist, and that reenlistment bonus funding will keep pace with the numbers of personnel reaching key reenlistment points. 2/

The magnitude of the changes in experience profiles projected here raises some questions about the services' willingness to accede to them, and thus about the validity of the above assumption. 3/ Restricting reenlist-

2. The assumption also implies that new recruits will distribute themselves among initial tour lengths as they did in 1985, and that the tour lengths required of reenlistees will not change.

3. This is most true for the Marine Corps, but because it is the smallest service this study did not explore the sorts of policies that could be implemented to restrict seniority growth. The Army tightened reenlistment standards in 1983 and 1984, but this apparently was done to weed out marginal performers rather than to reduce seniority growth.

ments, however, would put greater pressure on recruiting. This would not be desirable in the 1990s, when enlistment-age cohorts will be smaller than they have been in the 1980s.

Accession Levels. If reenlistment policies do not change, then accession levels--the numbers of new recruits brought in--will have to be adjusted to accommodate desired strength levels. 4/ Strength increases, for example, would be achieved by increasing accessions rather than by easing reenlistment standards or offering additional inducements for reenlistment. Accession adjustments would be feasible, as the requirements generated under all of the options considered here are modest by historical standards.

Enlisted Strength Plans. The projections shown in Figure 2 assume that the Congress will authorize the enlisted force sizes envisioned in the services' budget submissions for fiscal year 1988. These submissions call for modest growth in Marine Corps personnel strength, more substantial growth for the Navy, a small drop in Air Force strength in 1988, and an essentially constant size for the Army. Figure 3 shows the plans in terms of percentage changes from 1987 strength levels. Small deviations from these plans--1 percent or 2 percent, for example--would not markedly affect the experience distributions of the forces.

Supply-Side Factors

When employment conditions in the civilian economy change, military retention rates are affected. Private-sector pay increases that are not matched by raises in the military cause more service members to leave, as does falling civilian unemployment. The projections of the services' experience structures through this report reflect adjustments for the effects of projected changes (described below) in these two factors. 5/

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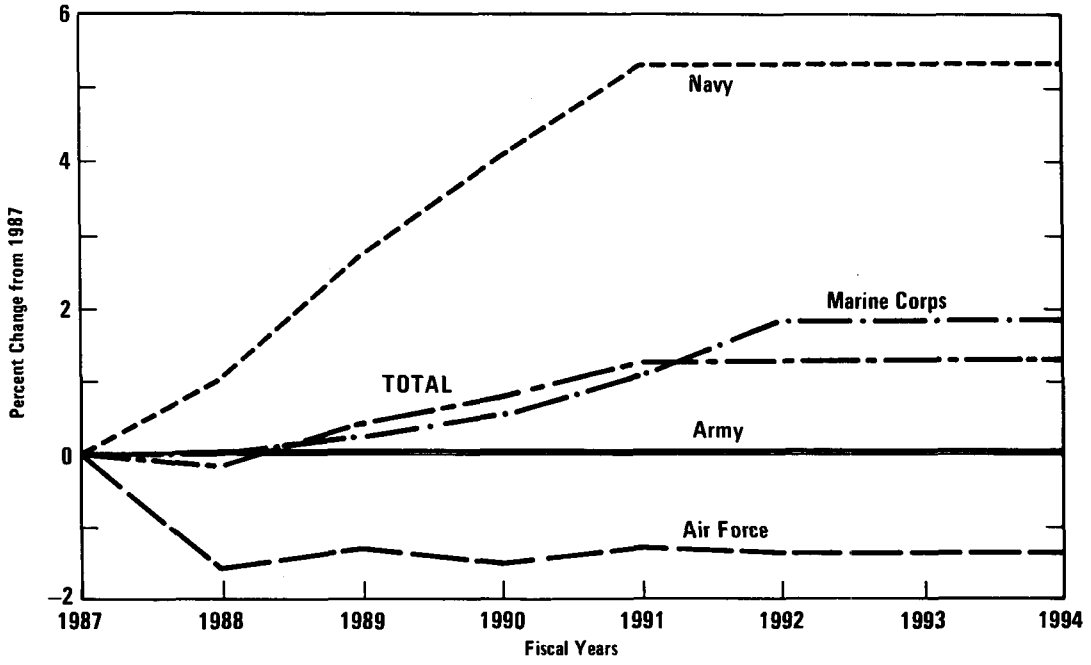
4. This study assumed that neither these adjustments, nor outside factors such as the declining size of enlistment-age cohorts, would alter the demographic mix of entering recruits (including education and test scores). This implies that there will be a modest increase in recruiting resources. Even without this increase, however, the demographic mix probably would not change enough to affect significantly the projections of experience structures.

5. The projections assume that the stay/leave decisions only of those members completing their current enlistment tours in a given year would be affected by outside factors. Most changes in status--extensions, reenlistments, losses--occur among this group.

Figure 3.
Planned Changes in Enlisted Strengths from 1987 Levels



SOURCE: Department of Defense (through 1992).

The effects of changes in pay and civilian unemployment were derived from statistical estimates for the parameters of a model of retention decisions called the Annualized Cost-of-Leaving (ACOL) model. This model assumes that the underlying preferences of individual service members for military as against civilian employment are constant over time. 6/ Appendix A gives the full set of pay and unemployment effects that were used.

Military Pay Levels. For this study, it was assumed that military pay raises would be given on October 1 of each year and would match private-sector

6. For a description of the model, see Department of Defense, Office of the Secretary of Defense, *Fifth Quadrennial Review of Military Compensation*, Volume 1B, "Supporting Appendixes to Uniformed Services Retirement System," Appendix I (January 1984). The present study used computer software and data developed for this Review. A brief description of the ACOL model appears in Congressional Budget Office, *Elimination of Double Tax Benefits for Military Homeowners* (March 1986). For a theoretical development and comparison of alternative models, including the ACOL, see John T. Warner, *Military Compensation and Retention: An Analysis of Alternative Models and a Simulation of a New Retention Model* (Arlington, Va: Center for Naval Analyses, CRC-426, August 1981).

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pay increases during the preceding years. One exception to this rule is 1988; as this report was prepared, it seemed likely that the 1988 raise would be 3 percent on January 1, 1988, slightly smaller than the projected private-sector increase in 1987. After 1988, the assumed matching requires real growth in military pay of about 1.5 percent per year. 7/

Civilian Unemployment. CBO's projections show a gradual drop in civilian unemployment to 5.8 percent in 1991.

COST PROJECTIONS

This study projects a rise of roughly 5.3 percent in real personnel costs between 1987 and 1992--about $2.6 billion in 1987 dollars--with continued increases thereafter. Table 1 shows the cost estimates for the enlisted force projections presented in the first section of this chapter, aggregated into 12 broad categories. 8/ The cost totals should not be confused with the military personnel costs in CBO's baseline projections of the federal budget, which implicitly assume no seniority growth and no personnel strength changes. These factors are accounted for in the Administration's budget request, but the projections here differ from the Administration's because of differences in assumptions and in the treatment of inflation.

Basic pay and its associated allowances for quarters (BAQ) and subsistence (BAS) account for more than half of the total personnel costs identified in the table. They account for an even larger share of cost growth, in part because the economic assumptions stated above imply modest real growth in military pay. Virtually all of the cost growth appears in the direct

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7. Congressional Budget Office, *The Economic and Budget Outlook: Fiscal Years 1988-1992* (February 1987).

8. Although enlistment and reenlistment bonuses are normally included in personnel costs, this study did not attempt to project costs for these programs. Bonuses are designed to correct shortages in specific military occupations, a level of detail that was beyond the scope of this study. As noted in the previous section, an implicit assumption about aggregate levels of reenlistment bonuses underlies the projections of retention rates, but that assumption could not readily be translated into cost projections.

TABLE 1. ENLISTED PERSONNEL COST PROJECTIONS BY CATEGORY, FOUR-SERVICE TOTAL, 1987-1994
(In billions of 1987 dollars)

Category	1987	1988	1989	1990	1991	1992	1993	1994
Basic Pay	22.0	21.9	22.3	22.7	23.2	23.7	24.1	24.6
Basic Allowance for Quarters	2.7	2.7	2.8	2.8	2.9	3.0	3.0	3.1
Basic Allowance for Subsistence	3.0	2.9	3.0	3.0	3.1	3.1	3.2	3.2
Other Pays	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Other Allowances	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Social Security Payroll Tax (FICA)	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9
Permanent-Change-of-Station Travel	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Other Costs	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Retired Pay Accrual	11.5	11.2	11.2	11.2	11.3	11.4	11.6	11.8
Individual Training	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Recruiting and Examining	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Medical Costs	3.4	3.4	3.4	3.5	3.6	3.7	3.7	3.8
Total Cost	49.5	49.1	49.8	50.5	51.4	52.2	53.0	53.9

SOURCE: Congressional Budget Office.

pay categories and in others that are tied, formally or informally, to basic pay. 9/ This study assumed that cost elements not tied to basic pay, such as the cost per PCS move, would not change in real terms, although total costs in these categories could vary with changes in strength levels. Minor variations would be evident in some of these nonpay categories if the figures were not rounded to the nearest $100 million.

Sources of Cost Growth

Table 2 breaks down the cost increases over 1987 levels into components associated with five factors: the richer mix of pay grades that may come with seniority growth; higher average pay levels because of longevity increases in basic pay; changes in personnel strengths; changes in real pay levels; and changes in retirement accrual rates. The first two, which together make up the cost of seniority growth, are discussed in detail in the next section.

Increases in real (inflation-adjusted) pay rates are the biggest single factor in raising enlisted personnel costs, accounting for more than 60 percent of projected cost growth. In the 1990s, annual increases of roughly $700 million (1987 dollars) will be required if military pay is to keep pace with private-sector pay. Pay raises also affect the cost growth attributable to other sources: personnel strength increases, for example, become more costly.

Major cost savings should result from the enactment, in 1986, of a less costly retirement system. Although the system applies only to those who entered after August 1, 1986, they will make up an increasing share of all personnel. The growing coverage of the new system contributes to a steady reduction in the percentage of basic pay--the normal cost percentage--that the Defense Department projects must be set aside to fund military retirement.

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9. Categories tied to basic pay include BAQ, BAS, Social Security tax payments (FICA), separation pay, unemployment benefits, the accrual charge for military retirement, and (under the assumptions of this study) medical costs. The accrual charge is computed as a percentage of total basic pay--the so-called "normal cost percentage"--and thus will rise or fall in real terms with basic pay. In addition, however, the percentage figure that DoD uses can vary from year to year as the structure and retention rates of the personnel force vary, and will fall as a less costly retirement system, enacted in 1986, covers a growing percentage of personnel. This study used DoD's projections of the normal cost percentage, which show a drop from 52.2 percent in 1987 to 47.8 percent in 1992 (the latter figure was assumed to apply in 1993 and 1994 as well). The falling percentage explains why costs for retired pay accrual do not rise proportionately with basic pay.

TABLE 2. SOURCES OF GROWTH IN PERSONNEL COSTS OVER 1987 LEVELS (In millions of 1987 dollars)

Source of Growth	1988	1989	1990	1991	1992	1993	1994
Richer Grade Mix	90	100	180	220	300	360	430
Longevity Pay Increases	220	220	250	300	420	520	570
Personnel Strength Changes	-70	220	390	630	660	670	680
Real Pay Changes	-430	210	760	1,520	2,240	2,920	3,620
Changes in Retired Pay Accrual Rates a/	-220	-440	-640	-840	-970	-970	-970
Total	-410	310	930	1,830	2,640	3,500	4,330

SOURCE: Congressional Budget Office.

NOTE: The figures in each line were calculated under the assumption that the sources of growth in the lines above had been eliminated. Altering the order of computation would cause minor changes in the figures.

a. Effects of changes in the normal cost percentage used in calculating the accrual charge for retired pay.

Personnel strength changes account for about one-quarter of the cost increases through 1991, when the Navy's planned growth will end. The small cost reduction in 1988 reflects a planned cut in Air Force enlisted strength in that year.

THE COSTS OF SENIORITY GROWTH

Seniority growth could add $720 million to personnel costs in 1992, and $2.3 billion over the five years 1988 to 1992. 10/ The two components of these increases--changes in the mix of pay grades and higher average pay levels within grades--are not equally likely, however, as the discussion below makes clear.

10. The CBO baseline projections of the federal budget, used by the Congress in the budget process, implicitly assume that there will be no seniority growth. Thus, the cost increases may be interpreted as additions to the CBO baseline projections.

TABLE 3. PERCENT DISTRIBUTION OF ENLISTED FORCES BY PAY GRADE, 1985 ACTUAL AND 1992 PROJECTED

Pay Grade	Army		Navy		Marine Corps		Air Force	
	1985	1992	1985	1992	1985	1992	1985	1992
E-1 to E-3	29.8	29.4	32.9	32.2	51.2	48.9	31.4	30.9
E-4	29.0	28.5	20.9	20.4	18.1	16.5	23.7	21.1
E-5	17.5	17.1	20.8	19.0	13.9	13.8	22.7	22.7
E-6	13.0	12.5	15.9	16.9	8.7	9.8	11.7	13.7
E-7	7.8	9.1	6.6	8.2	5.2	7.3	7.6	8.5
E-8 and E-9	2.9	3.5	2.9	3.3	2.8	3.8	2.9	3.0

SOURCE: Congressional Budget Office based on data from Defense Manpower Data Center.

Changes in the Mix of Pay Grades

A more senior force will naturally mean a larger percentage of personnel in the senior pay grades unless either smaller percentages of personnel are promoted to the senior grades or promotion to those grades is delayed. In estimating costs, this study assumed that the 1987 mixes of grades within years of service would be maintained (although the grade mix for all personnel would change as seniority grows). This is roughly equivalent to assuming that promotion rates and timings remain as they were in the early 1980s.

Under the promotion assumption, this study projects substantial increases in the percentages of senior NCOs--those in grades E-7 and above--between 1985 and 1992 (see Table 3). 11/ The Navy, for example, shows a rise from 9.5 percent to 11.5 percent, and the Army from 10.7 percent to

11. This study did not formally model the enlisted promotion process. It derived the percentages for 1992 by applying estimated 1987 distributions of grades within each year of service to the projections of 1992 year-of-service distributions. This procedure should approximate the effects of maintaining the promotion practices that led to the 1987 grade distributions. The 1987 estimates were formed by combining detailed information on 1985 distributions with less detailed information for 1987 published by the services.

12.6 percent. 12/ The percentage of mid-level NCOs--those in grade E-6--is also projected to rise in every service but the Army.

Personnel Costs. The projected shift in the grade distributions adds $300 million to personnel costs in 1992 (see Table 4), relative to what costs would be if the aggregate mix of pay grades in each service stayed as it was in 1987. 13/ This amounts to roughly 0.6 percent of total personnel costs. Over the five-year period 1988 to 1992, the grade shift adds a total of nearly $900 million to costs. It continues to raise costs well beyond the period of the projections, driven primarily by continued seniority growth in the Navy and Marine Corps.

Promotion Cuts. Experience suggests that some growth in the numbers of senior NCOs will take place, but it may not be as great as the projections indicate. The number of enlisted members in the two highest grades cannot legally exceed 3 percent in any of the services, a constraint that is violated by three of the services in the projections. Limits on the percentages in the top six grades (E-4 and above), which are not legally binding, might also be violated, although for the most part the shifts occur within the top six grades. The Marine Corps is the obvious exception to this generalization, as shown by the substantial drop for its lowest three grades.

Slowing promotions to maintain the 1987 grade distributions, and thus eliminate the costs projected in Table 4, would require delays for several grades. In the Marine Corps, for example, personnel in grade E-5 would have to serve about 21 months longer in the 1990s than in the past before being promoted to E-6. They would then spend a few months less in that grade than in the past, but their total time in service before promotion to E-7 would still be well over one year greater. 14/ Delays would be shorter in the Army and Navy (roughly six months to one year more time in service

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12. If legal limits on the percentage of enlisted personnel in grades E-8 and E-9 were not relaxed, all of the projected growth would have to appear in grade E-7. Adjusting for this would not have a major effect on the cost projections (below) because of the small numbers of personnel involved.

13. This assumes no change in retention rates in response to promotion delays or reduced promotion rates. Reduced retention would tend to cut costs further, for given enlisted strength levels.

14. The delays given are the differences, between 1987 and 1992, in the year and month of service at which half of the personnel remaining have been advanced to the next higher grade. Because they were not derived from a formal model of promotion, the numbers are approximate and would not correspond exactly to changes in promotion timing as calculated by the services.

before promotion to E-6 and E-7) and shortest in the Air Force. Alternatively, reduced promotion rates could achieve similar savings.

The cost figures in Table 4 can be viewed as potential savings, savings that could be realized without forcing mid-level NCOs to leave and thus losing the advantages of their experience. 15/ The second component of seniority-growth cost is more inevitable, arising primarily from the structure of the military basic pay table.

Longevity Increases in Basic Pay

The military basic pay table incorporates longevity increases--that is, pay raises that automatically occur as a member's years of service rise, even if the member is not promoted to a higher grade. As a result, increased seniority means increased basic pay costs even when the aggregate distribution of grades within each service is held constant. Other cost elements also grow--medical care costs, for example (in part because older personnel tend to have more dependents). 16/

Longevity increases in pay, and increases in other cost categories affected by the year-to-service distributions of enlisted personnel, will contribute $420 million to personnel costs in 1992, and more than $1.4 billion over the five years 1988 through 1992 (see Table 5). 17/ In 1992, the last year of the Five Year Defense Plan, personnel costs will be almost 1 percent higher than they would be if the 1987 experience structures were maintained. Cost growth would continue in 1993 and 1994, and probably well beyond the end of the projection period.

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15. Some would choose to leave, of course, because slowed promotion would reduce their future military pay. Reduced retention would tend to increase the savings, at the cost of lost experience. As noted above, this study ignored the retention effect in projecting the cost savings under slowed promotion. Available studies of retention tend to derive their predictions of the effects of changing promotion policies--if they do so at all--from assumptions about members' rates of time preference.

16. Some costs fall--training costs, for example--because more senior personnel have lower loss rates, but these reductions are small compared with the increases in pay costs.

17. These estimates result from projecting the costs of the 1987 forces in each future year, adjusting the factors determining costs--accessions, losses, personnel by year of service --in proportion with planned strength changes. These costs were compared with the costs of the projected forces (Figure 2), under the assumption that the aggregate mix of grades within each service would be the same as in 1987 (that is, the service-specific costs underlying Table 1 less the grade-mix costs in Table 4).

TABLE 4. PROJECTED COSTS OF SENIORITY GROWTH ARISING FROM MAINTAINING PROMOTION RATES AND TIMINGS

Service	1988	1989	1990	1991	1992	1993	1994
				In Millions of 1987 Dollars			
Army	20	40	60	80	90	100	100
Navy	20	10	30	40	80	110	140
Marine Corps	10	30	50	60	70	90	110
Air Force	40	20	40	40	60	70	80
Total	90	100	180	220	300	360	430
				As a Percent of Personnel Costs			
Army	0.1	0.2	0.4	0.4	0.5	0.5	0.5
Navy	0.1	0.1	0.2	0.3	0.5	0.7	0.9
Marine Corps	0.3	0.6	1.0	1.3	1.5	1.9	2.2
Air Force	0.3	0.2	0.3	0.3	0.5	0.5	0.6
Total	0.2	0.2	0.3	0.4	0.6	0.7	0.8

SOURCE: Congressional Budget Office.
NOTE: Numbers may not add to totals because of rounding.

TABLE 5. PROJECTED COSTS OF SENIORITY GROWTH ARISING FROM LONGEVITY INCREASES IN PAY

	1988	1989	1990	1991	1992	1993	1994
				In Millions of 1987 Dollars			
Army	20	50	70	100	120	130	140
Navy	50	40	50	70	150	200	230
Marine Corps	50	40	50	60	80	90	110
Air Force	110	90	80	70	80	110	100
Total	220	220	250	300	420	520	570
				As a Percent of Personnel Costs			
Army	0.1	0.3	0.4	0.5	0.6	0.7	0.7
Navy	0.4	0.3	0.3	0.4	1.0	1.3	1.5
Marine Corps	1.1	1.0	1.2	1.4	1.7	1.9	2.2
Air Force	0.8	0.7	0.6	0.5	0.5	0.7	0.7
Total	0.4	0.5	0.5	0.6	0.8	1.0	1.1

SOURCE: Congressional Budget Office.
NOTE: Numbers may not add to totals because of rounding. Figures include changes in all cost categories that are affected by the year-of-service mixes of the enlisted forces.

The service breakdowns show patterns consistent with the year-of-service projections displayed in Figure 2. The Air Force dominates the total cost growth in the early years because its planned strength cut in 1988 will immediately reduce the percentage of lower-paid junior personnel in its enlisted force. The Navy accounts for the largest share beginning in 1992 as it completes its enlisted strength buildup and reduces its annual accession requirements. Throughout the projection period, Marine Corps costs for seniority growth are largest as a percent of the service's total personnel costs. As Figure 2 showed, the Marine Corps is projected to have the greatest growth in senior NCO strength. Moreover, most of that growth comes implicitly at the expense of the lowest-paid group, those in their first enlistment terms.

Unlike the costs in Table 4, the estimates in Table 5 do not indicate the savings that would result from any specific set of policies. Growth in experience could be slowed, of course, but maintaining 1987's year-of-service structures even roughly would prove very difficult. Nonetheless, the costs in Table 5 provide a useful benchmark against which to assess the productivity gains that are the subject of Chapter III.

CHAPTER III

EXPERIENCE AND PRODUCTIVITY

Chapter II showed that growing seniority will be an important trend in the enlisted forces in the late 1980s and early 1990s. It also showed that this growth will add an average of between $450 million and $800 million dollars per year to personnel costs in 1991 through 1994, depending on promotion and other policies. This chapter raises the question: Are the returns to greater seniority sufficient to justify the added costs?

The data available to address the question are very limited. This may seem surprising, given that the shift toward a more senior force has been under way since the start of the All-Volunteer Force. The lack of data reflects the ways in which the services determine how many personnel they require and at what experience levels. The key term is "require": the notion of requirements assumes that there is one best way to staff any function. Any shortfalls, such as giving a unit fewer personnel even though they have a richer experience mix than the stated requirement, are assumed to degrade performance. Although in a steady state this approach is probably appropriate for the services' personnel programming functions, it does not lend itself to deriving trade-offs among personnel of different experience levels. 1/

Fortunately for the purposes of this study, two attempts to measure productivity at various levels of experience have yielded useful information. The Enlisted Utilization Survey (EUS), conducted by the RAND Corporation for the Defense Advanced Research Projects Agency in the mid-1970s, examined productivity growth during the first enlistment term for a variety of enlisted specialties in the Army, Navy, and Air Force. Subsequent analyses of the data at RAND and at the Center for Naval Analyses (CNA) revealed strong relationships between experience and productivity. 2/ The second

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1. It also limits the manpower system's flexibility, a point that is raised in the final section of this chapter.

2. Gus W. Haggstrom, Winston K. Chow, and Robert M. Gay, *Productivity Profiles of First-Term Enlisted Personnel* (Santa Monica, Calif.: The RAND Corporation, N-2059-RC, February 1984). Alan J. Marcus and Aline O. Quester, "Determinants of Labor Productivity in the Military" (Alexandria, Va.: Center for Naval Analyses, November 1984).

attempt, also a RAND study but in this case performed for the U.S. Air Force, found substantial productivity growth over a full range of experience levels. 3/ These two studies are described in greater detail below.

A third study, which followed a very different approach from the first two, confirms that the experience/productivity relationships found in the above studies are not simply a result of their survey-based approaches. In those two studies, supervisors were asked to rate the performances of the personnel working under them. The third study, an examination of various occupational specialties aboard Navy ships, relied on a more objective output measure: the amount of time that major systems served by personnel in the selected specialties were not fully operational. 4/ These downtimes were related to the characteristics of the personnel servicing the systems, including in each case some measure of average experience. The results are not directly usable in the present analysis because of the forms of the experience measures, but some statistically significant relationship between experience and output was found for all but one of the enlisted specialties examined. 5/

The next two sections describe the two studies that provide the productivity data for this examination, showing how they were used to derive service-specific indexes of productivity by year of service. Most of the details are relegated to Appendix B; what appears below is required for an understanding of the limitations that the available data impose on the conclusions drawn in the next chapter. The third section presents the major results of this chapter: projections of aggregate productivity levels for each of the services. The final section discusses the major limitations of the data and, by extension, of the productivity projections.

THE ENLISTED UTILIZATION SURVEY

In the EUS, 27,000 first-term enlisted personnel were first asked to identify their immediate supervisors. In a written survey, those supervisors were

3. S. Craig Moore, *Demand and Supply Integration for Air Force Enlisted Work Force Planning: A Briefing* (Santa Monica, Calif.: The RAND Corporation, N-1724-AF, August 1981).

4. Stanley A. Horowitz and Allan Sherman, *Crew Characteristics and Ship Condition* (Alexandria, Va.: Center for Naval Analyses, CNS 1090, March 1977).

5. Another study employing an objective performance measure is: A. J. Marcus, *Personnel Substitution and Navy Aviation Readiness* (Alexandria, Va.: Center for Naval Analyses, Professional Paper 363, October 1982). The results indicated that, at the margin, personnel in grade E-7 and above are several times more productive than personnel in the junior NCO grades. This is too large a difference to be accepted without confirming studies.

then asked to estimate the net productivity of the first-termers identified in the first round at four points during their initial tours. 6/ The survey explained that net productivity means the contribution of the individual to the unit's output after accounting for the supervision time that the individual requires. Productivity was measured relative to that of a fully trained "journeyman," someone with exactly four years of service completed.

The RAND analysis of the EUS data derived usable results for occupational specialties in all three of the services surveyed, including 16 in the Army, 10 in the Navy, and 22 in the Air Force. Each specialty had been designated in the original survey effort as either high-, medium-, or low-skill, to assure a broad sample of skills in each service. For various reasons, the responses of many supervisors were excluded, leaving usable data for 9,272 individuals. 7/ For each specialty, RAND averaged the productivity estimates among respondents at each of the four time-in-service points, and then fitted standard learning curves to the four values.

The CNA analysis of the same EUS data used different methods but yielded results on the relationship between experience and productivity that were remarkably similar to those of the RAND study. Averaging among Navy specialties yields a total productivity over the four years of a first term, expressed in journeyman-equivalent man-years, of 2.28 years for the RAND analysis and 2.34 years for the CNA analysis. 8/ Given the range among specialties--from roughly 1.8 to 2.8--this difference in the averages is very small. Because of the small differences, and for consistency among the services, this study relied exclusively on the RAND results.

The aggregate learning curves derived from the RAND analysis, shown in Figure 4, appear plausible. The curves indicate the average productivity during each year of service, expressed--as it was by the rating supervisors--

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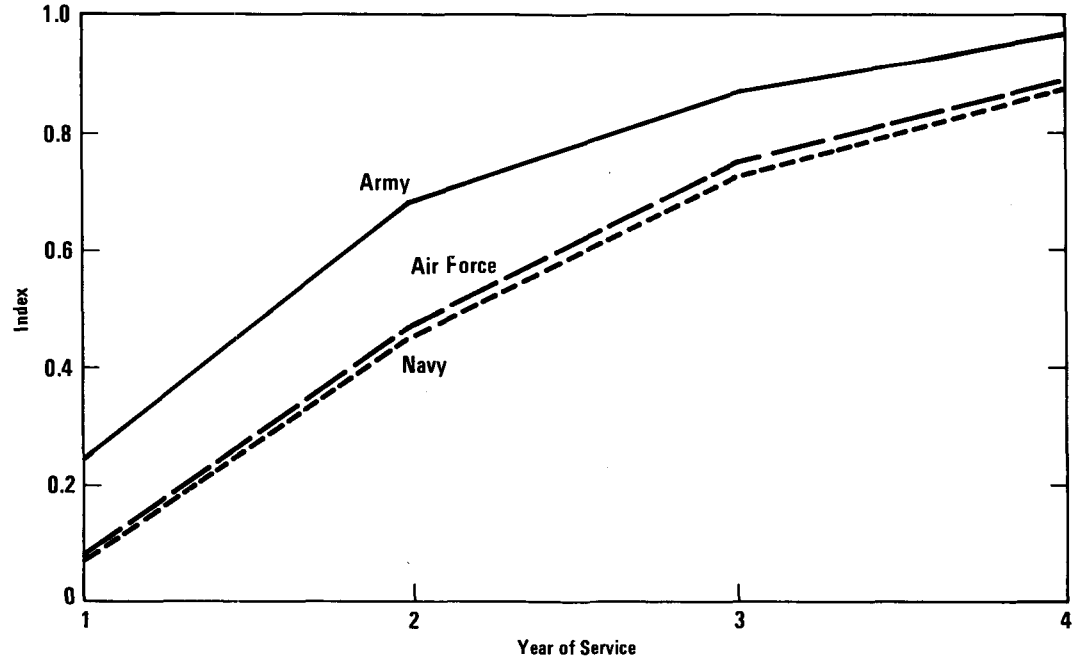
6. The four points were: during the individual's first month at his initial duty station; at the time of the rating; one year after the rating; and after four years of service. Ratings of "typical" first-termers were also solicited, although these were not used in the current study. The typical enlistees were generally rated as less productive, on average, than the specific individuals.

7. The exclusions were made to ensure that: the supervisor had a reasonable basis for providing estimates for the individual's entire first term; technical school graduates were being evaluated in the specialty for which they were trained; necessary data for the analysis were available; and the supervisors correctly understood the concept of relative net productivity.

8. The largest difference for any individual specialty was 0.23 man-years; in most cases the differences were much smaller.

Figure 4.
Productivity Indexes by Service and Year of Service



SOURCE: Congressional Budget Office, from the RAND Corporation.
NOTE: Productivity is measured relative to that of a typical enlistee who has completed four years of service.

as a fraction of the productivity of a fully trained journeyman (that is, a typical individual who has just completed four years of service). 9/

As should be expected, average productivity is very low during the first year of service. This results from the combination of low productivity once the recruit reaches his first duty station, and the several months of training time that precede the first assignment. Productivity during training is assumed to be zero. 10/ The higher values for the Army than for the

9. Because the indexes measure average productivity over the course of the given years of service, the values in the fourth year are less than one. In addition, estimated productivity at the end of four years could differ from one because this study used the results for actual recruits, rather than for "typical" recruits. The reference person in both cases (the fully trained journeyman) was a typical enlistee with four years of service completed.

10. Net productivity during formal training, basic and advanced, would actually be negative because of instructors' time inputs. This study did not attempt to take account of changes in aggregate productivity arising from changes in the total number of instructors required as accession levels vary.

other two services are consistent with the view that Army jobs are more easily learned. It should be noted, however, that the EUS data do not provide a clear indication that the skill level of a specialty (as determined in the original survey project) affects productivity.

Lacking any direct information on productivity in the Marine Corps, this study used the Army index for that service.

The age of the EUS data (the survey was conducted in 1975) is a cause for concern about their applicability to today's forces. Inevitably, it limits the conclusions that can be drawn about the future productivities of the enlisted forces. The final section of this chapter discusses these limitations.

THE RAND AIR FORCE STUDY

Like the EUS, the study performed for the Air Force was survey-based, but there the similarity ends. A demonstration effort, it examined only one specialty. It collected data on completion times for 26 separate groups of tasks typically performed by personnel in that specialty. Most important, the data covered personnel classified into six "labor types," covering a full range of experience, rather than just personnel in their first terms. 11/

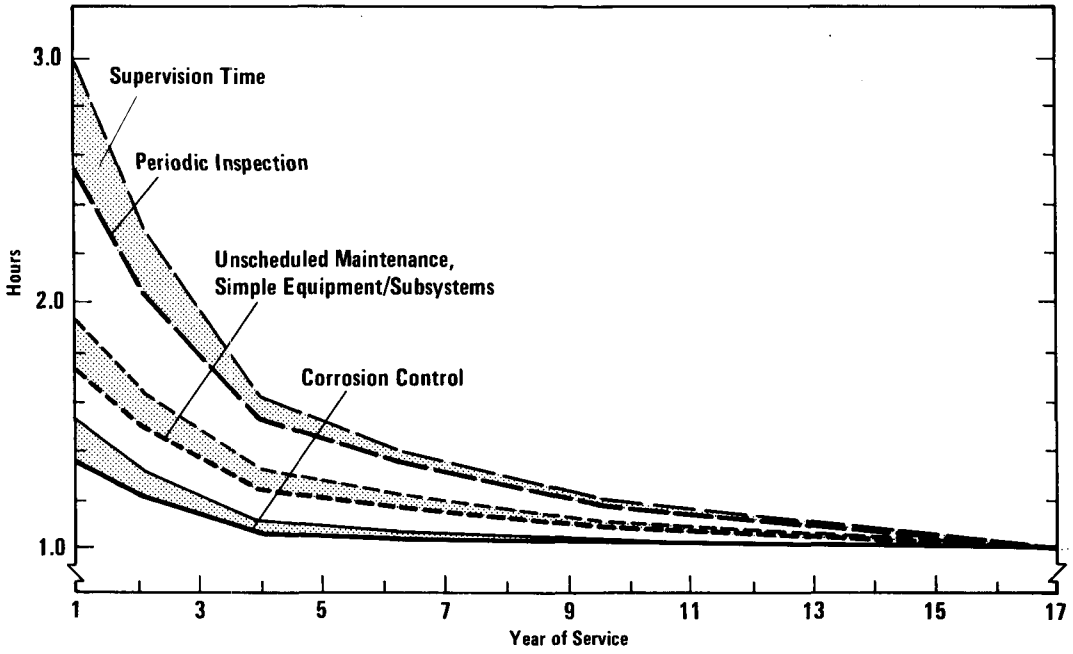
The study was intended to demonstrate how requirements for personnel of different skill levels and grades could be changed to improve the match between requirements and available supplies. The data collected were similar, but not identical, to data routinely collected within the Air Force's Management Engineering Program. The single specialty, Aerospace Ground Equipment (AGE) Maintenance, was one of two areas selected as broadly representative prototypes. 12/ In the EUS, this specialty was identified as "medium-skill."

The nature of the data collected is illustrated in Figure 5, which gives relative completion times by year of service for three representative task groups: periodic inspection, unscheduled maintenance (simple equipment/subsystems), and corrosion control. All times are measured relative to the time required by a person in the highest labor type (the plotted points

11. Labor types were defined by a combination of pay grade and skill level, an Air Force measure of proficiency.

12. The project was halted before data were collected for the second area, General Accounting.

Figure 5.
Relative Task Completion Times



SOURCE: Congressional Budget Office, from RAND Corporation data.
NOTE: Thin lines include supervision time.

are at the average year of service for each labor type). Two lines appear for each task group; the upper line includes the supervision time required. For example, the top pair of lines shows that a person in the lowest labor type, who on average would have completed one year of service, requires 2.5 hours to perform a periodic inspection job that the most experienced person could complete in one hour. In addition, the equivalent of 0.5 hours of the junior person's time would be required for supervision of the work. 13/ For corrosion control, the advantage of experience is much less, particularly beyond the fourth year of service.

The detail of the data presents problems for the derivation of a single aggregate index of productivity by year of service. It is not sufficient simply to calculate such an index separately for each group of tasks and then to average the indexes at each year of service; to do so would be to assume, implicitly, that the time of every member is spread across tasks in the same proportions. In an actual work center, task assignments would be made more rationally, with experienced personnel assigned primarily to tasks in which their performance advantages over junior personnel are

13. The supervision would be performed, of course, by a more senior person.

greatest, and junior personnel to tasks in which their disadvantages are least. Most corrosion control work, for example, would be performed by those who have just completed their school training, and most periodic inspection by seasoned career personnel.

This study mirrored the task assignment process that would take place in a work center through the techniques of linear programming. The goal was to accomplish the required amount of work on each task while minimizing the total number of personnel required, subject to a number of constraints. The constraints reflected practical considerations that would prevent the achievement of the most efficient short-run solution, such as the need to provide junior people with the opportunity to gain experience in the more complex tasks. An additional constraint ensured that the mix of personnel by labor type would be the same as that found in the work centers when the data were collected.

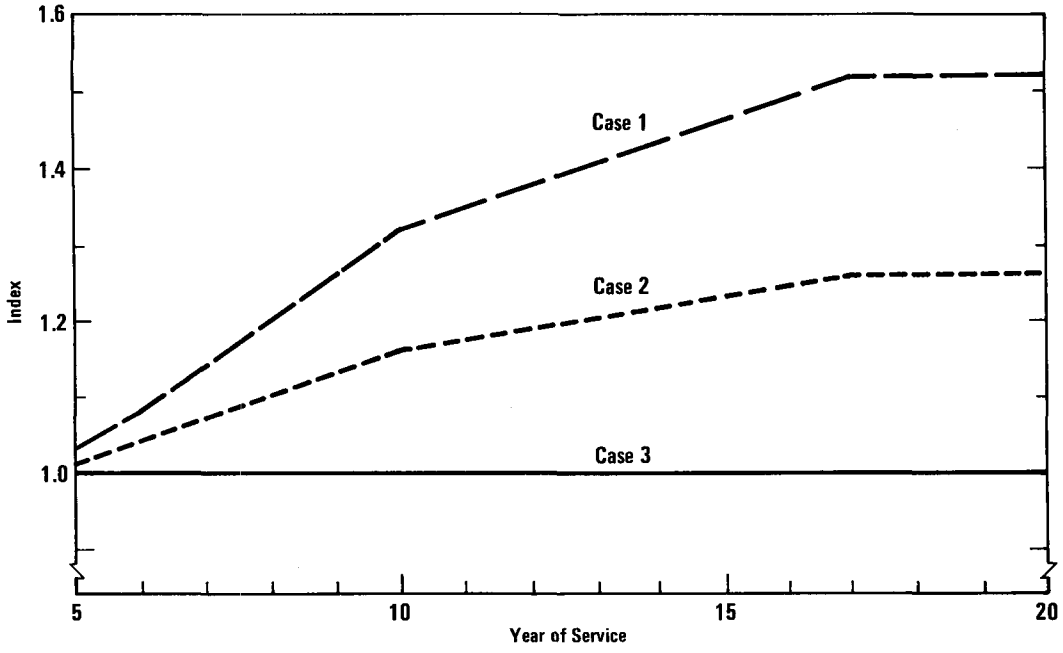
The linear programming procedure provided measures of the relative marginal productivities of personnel in the various labor types. With these values assigned to the average time in service for the labor types, linear interpolation yielded the required index of productivity at each year of service.

Because the constraints imposed in the linear program affected the results, and because choosing an appropriate set of constraints involved some judgment, two alternative indexes were developed. One of these, denoted "Case 1," reflected an attempt to match the set of constraints identified in the original study. The second, "Case 2," simply halved the improvement at each year of service over the reference point, the end of the fourth year, to illustrate the effects of assuming lesser effects of experience on productivity. Case 2 also approximated the results under an alternative set of constraints that also appeared to be plausible. A final index, "Case 3," arbitrarily held productivity constant at its value for the end of the fourth year of service, thus assuming no relationship between experience and productivity beyond the first term.

Figure 6 displays the three productivity indexes. The line for Case 1 shows the most senior personnel as being roughly 52 percent more productive than the reference person, the same journeyman as used in the EUS. This is a smaller return to experience than was estimated in a previous CBO study, based on earnings growth in the private sector (see the discussion in Chapter I). 14/ Also, the data can support even higher estimates of the

14. Congressional Budget Office, *Quality Soldiers: Costs of Manning the Active Army* (June 1986).

Figure 6.
Productivity Indexes by Year of Service



SOURCE: Congressional Budget Office.

NOTE: Productivity is measured relative to that of a typical enlistee who has completed four years of service.

return to experience. 15/ Thus, Case 1 represents not an upper bound, but rather a judgment as to the most likely relationship between productivity and experience in military jobs.

Case 2 represents a very conservative interpretation of the same results, conservative in the sense that it tends to minimize the estimated productivity gains that more senior forces will generate. Conservatism may be appropriate when these results, derived from data on a single Air Force specialty, are to be applied to all four services. Case 3 was added as an additional test of sensitivity. It might be taken as reflecting the agnostic position that the data are too limited to permit any conclusions to be drawn.

The three alternative indexes for years-of-service five and beyond were linked to the four service-specific indexes for years one through four

15. If no constraints are imposed on the task assignments of personnel at different skill levels, the trade-off between senior and junior personnel--roughly an 82 percent advantage of the most senior over someone with four years of service--approaches that on the task with the greatest difference in performance times.

described in the previous section. This resulted in three indexes for each service, reflecting the three alternative cases for the period after the first term.

PROJECTIONS OF AGGREGATE PRODUCTIVITY

All four services should show increased aggregate productivity in their enlisted forces by the early 1990s, even if productivity growth beyond the first term is small (Case 2) or nonexistent (Case 3). Figure 7 shows projections of productivity per person in the enlisted forces of each of the services, measured as percentage changes relative to 1985. The projections result from the mechanical application of the indexes described above to the year-of-service projections summarized in Figure 2 (Chapter II); the final section of this chapter discusses the limitations of this approach.

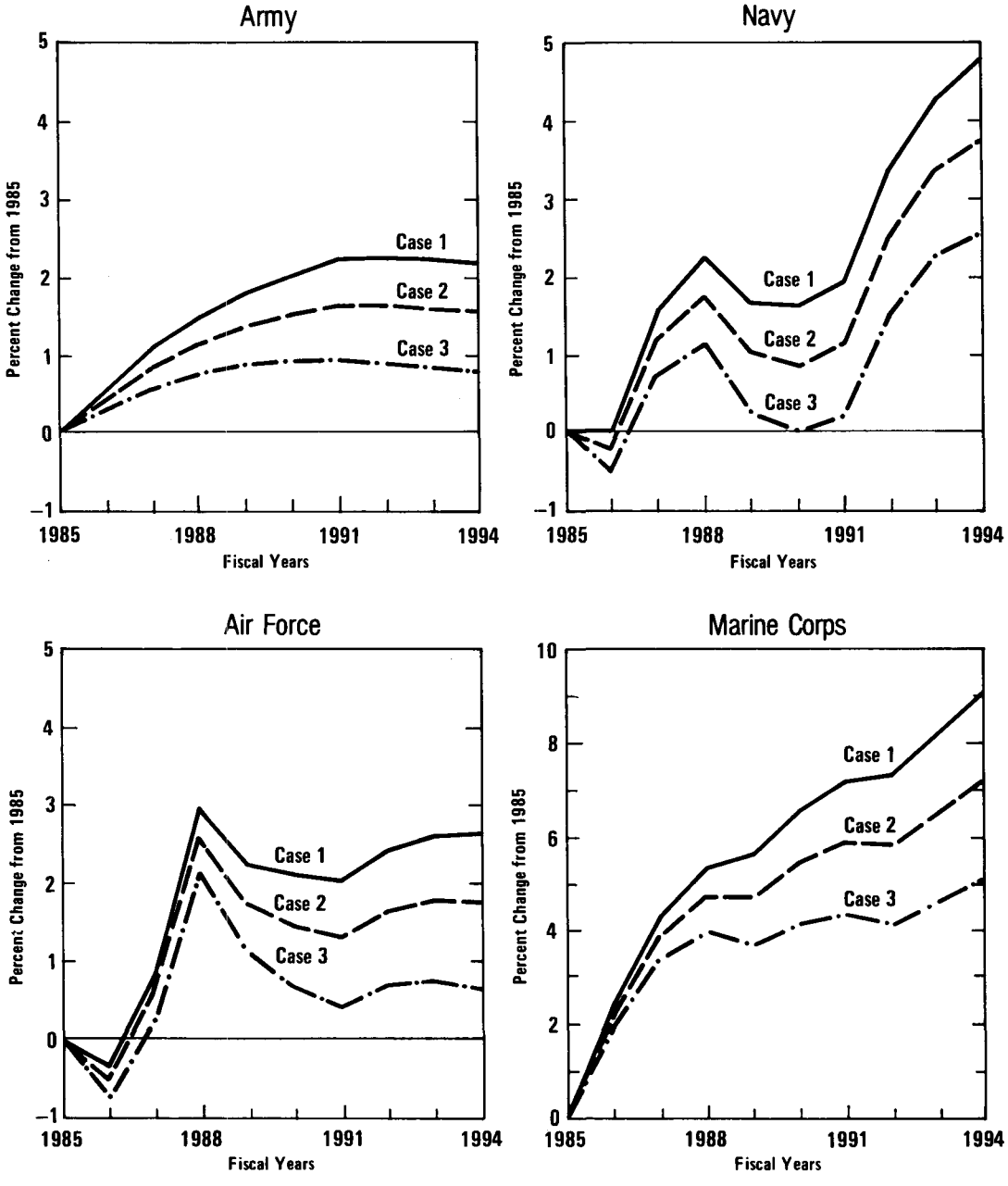
The largest productivity gains should be experienced by the Marine Corps. In 1992, the greater experience of the average Marine will make that person 7.4 percent more productive than his counterpart in 1985 and 2.9 percent more productive than in 1987 (Case 1). Under the more severe assumption of Case 3--no productivity growth beyond the first term--the gains will be more modest: 4.1 percent relative to 1985 and 0.7 percent relative to 1987. The Marine Corps gains are largest primarily because this study projects that it will undergo the most severe shift in its experience structure, with senior personnel in effect replacing first-termers.

Navy productivity gains probably would equal those of the Marine Corps were it not for the Navy's recent strength increases and its plans for additional increases in the future. The high accession levels needed (under the assumptions of this study) to support these strength increases tend to depress average productivity. After the planned growth is completed in 1991, Navy productivity should rise rapidly.

The Air Force projections for 1988 show an effect opposite to that observed for the Navy. The Air Force plans to cut strength by 8,000 in 1988. This should reduce its requirement for new recruits by about 10 percent relative to 1987, and so result in a temporary jump in average productivity.

Table 6 may help put the productivity gains in perspective, comparing the 1992 gains, relative to 1987, with the costs of the increased seniority that provides the gains. In 1992, personnel costs would be at least $420 million higher for the services combined--up to $720 million if promotion

Figure 7.
Projections of Average Productivity in the Enlisted Force of Each Service



SOURCE: Congressional Budget Office.

rates and timings did not change--than they would be if the year-of-service structures were the same then as in 1987. Excluding any effects of richer grade mixes, the cost increases should range from 0.5 percent for the Air Force to 1.7 percent for the Marine Corps. Productivity would grow twice as fast as costs under Case 1, and slightly faster than costs under Case 2. Only under the extreme assumption that senior career personnel are no more productive than someone just finishing the fourth year of service (Case 3) would the percentage cost increases exceed the percentage productivity gains. If projected changes in the grade mix are allowed to take place, however, costs could rise faster than productivity even under Case 1.

The returns to seniority growth can also be compared with total defense costs, of which the enlisted personnel costs examined in this study make up only about one-sixth. The added costs in 1992--$420 million to $720 million--represent only 0.14 percent to 0.24 percent of the 1987 defense budget. Even under the least favorable case, percentage productivity improvements would be several times larger.

That the returns to greater seniority may exceed the costs, in percentage terms, has no particular significance in this military context; notions of cost-effectiveness are not applicable to situations in which the returns (in this case, productivity) cannot be measured in the same units as the costs.

TABLE 6. SENIORITY GROWTH COSTS AND PRODUCTIVITY IMPROVEMENTS: 1992 VERSUS 1987

Service	Cost Increases a/		Productivity Improvements (In percent)		
	In Millions of 1987 Dollars	In percent	Case 1	Case 2	Case 3
Army	120 - 210	0.6 - 1.1	1.2	0.8	0.4
Navy	150 - 220	1.0 - 1.5	1.8	1.3	0.8
Marine Corps	80 - 150	1.7 - 3.2	2.9	1.9	0.7
Air Force	80 - 140	0.5 - 1.0	1.6	1.1	0.4

SOURCE: Congressional Budget Office.

a. Lower figures reflect seniority growth only, holding constant aggregate grade mixes; higher figures include projected increases in percentages of personnel in the senior pay grades.

What the results do indicate is that allowing the seniority growth probably would be a cheaper way of achieving small improvements in capabilities than, for example, adding 20,000 or 30,000 personnel to the enlisted forces while holding the year-of-service structures constant (assuming that were possible). Conversely, the results may be interpreted as suggesting that modest reductions in strength, relative to planned levels, would not reduce enlisted-force capabilities. This is the main subject of the final chapter of this paper. Before drawing firm conclusions, however, it is important to recognize the limitations of the underlying productivity data and their application.

LIMITATIONS AND QUALIFICATIONS

Five main factors limit the usefulness of the productivity indexes and the conclusions that may be drawn when they are applied to the enlisted force projections:

- The data are very skimpy, especially beyond the first term.
- The data, particularly those from the EUS, are now rather old; relationships that held in 1975 may no longer apply because of changes since then both in the quality of recruits and in the nature of the work they are asked to do.
- The indexes were derived from specialty-specific data, and so may not be entirely appropriate for application to an entire service.
- Relative productivity estimates are technically applicable only to experience mixes that are close to those from which they were estimated.
- Feasible productivity trade-offs may be limited by factors not considered here, such as manning requirements that are fixed because of past decisions on hardware designs, the small numbers of personnel in some work centers, and the inability of current military manpower systems to respond promptly and efficiently to changes in experience levels.

These factors are discussed in turn below. A concluding paragraph summarizes the discussion.

Skimpy Data

Results for one Air Force specialty hardly provide a sound basis for generalizations about aggregate productivity in each of the services. Clearly, more data on productivity growth beyond the first term are required. Nonetheless, the Air Force data are at least drawn from a military source rather than from the private sector, and the specialty examined is probably near the middle of the complexity spectrum among military jobs, not at one of the extremes. The clear indication in the data that productivity improves with experience suggests that the Case 3 indexes, although useful in measuring the sensitivity of results, do not represent the general situation in the military.

The more comprehensive EUS data would seem to be an adequate source of information on productivity growth during the first term. Additional data would be desirable, of course, especially if they were based on some objective output measure such as was available in the study of system downtimes on Navy ships. Further analysis of the EUS data would also be useful to answer more detailed questions, such as whether productivity on the job improves at different rates for recruits with different aptitudes and education.

Old Data

The time that has passed since the EUS data were collected in 1975 raises questions about their applicability to the forces of the 1980s and the 1990s. This is especially true for the Army, in which two conflicting effects have been felt. On the one hand, Army recruits in the mid-1980s have been, by any measure, better than their counterparts of a decade earlier; a much higher percentage now enter with high school diplomas, for example, and average scores on the aptitude tests administered to recruits have been higher. Evidence on the relationship between aptitude and first-term performance is not conclusive, but it seems likely that the average recruit of the 1980s can perform a given job better than his or her counterpart in the 1970s. 16/ On the other hand, Army jobs apparently have become more

16. Two studies indicating that higher-scoring recruits perform better are: Richard L. Fernandez and Jeffery B. Garfinkle, *Setting Enlistment Standards and Matching Recruits to Jobs Using Job Performance Criteria* (Santa Monica, Calif.: The RAND Corporation, R-3067-MIL, January 1985); and Barry L. Scribner and others, "Are Smart Tankers Better? AFQT and Military Productivity," *Armed Forces and Society*, vol. 12 (Winter 1986), pp. 193-206. Neither study found a strong time-in-service effect, but for the former this may have been due to problems in the performance measure. The "Tankers" study examined only a single occupational specialty. In Michael P. Ward and Hong W. Tan, *The Retention of High Quality Personnel in the U.S. Armed Forces* (Santa Monica, Calif.: The RAND Corporation, R-3117-MIL, February 1985), the effect of aptitude test scores

(Footnote Continued)

complex, which presumably would slow recruits' attainment of full proficiency. 17/ It is impossible to know which of these effects has been stronger.

Applying Specialty-Specific Results to an Entire Service

Two main problems arise when results for one or more specialties are applied to an entire service (aside from the obvious possibility that the specialties may not be sufficiently representative). The first--that experience in the current job is not the same thing as years of service--should not affect the results of this study. The second is more important: the performance of a unit--a battalion, a ship, or even a personnel records office--may not be determined solely by the productivities of the individuals in the unit.

Specialty changes are a common feature of military service because jobs differ in their retention patterns and in their needs for senior personnel. Naturally, members who change jobs will tend to be less productive initially in their new skill than they were in their old one, other things being equal. As a result, any index of productivity by experience level for a particular specialty that was based on years in that specialty would tend to overstate the returns to total service experience.

Fortunately, the data underlying the productivity indexes beyond the first term measured total service experience. 18/ Although the focus of the analysis was a job-specific experience measure, the study made for the Air Force reported average years of service for the individuals in each labor type. The years of service of members who had retrained--perhaps at their first or second reenlistments--were averaged together with the years for those who had never changed specialty. Thus, the productivity indexes reflect the pattern of specialty changes that led to the specific work force that was analyzed. To the extent that retraining into the specialty examined is not typical, of course, the indexes will be flawed, but that is just part of the general issue of how representative the specific skills are of the entire force, which is discussed above.

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16. on performance was negligible when speed of promotion was used as the performance measure and as a control for unobservable "quality." A summary of service efforts to measure on-the-job performance is available in: Office of the Assistant Secretary of Defense (Manpower, Installations, and Logistics), *Joint-Service Efforts to Link Enlistment Standards to Job Performance,* Third Annual Report to the House Committee on Appropriations (December 1984).

17. Martin Binkin, *Military Technology and Defense Manpower* (Washington, D.C.: Brookings Institution, 1986).

18. Although the experience measure in the EUS data was job-specific, specialty changes are not important enough during the first enlistment term for this to create a problem.

The second problem arises because few if any military units consist of individuals working independently on their separate tasks. Most work is cooperative, with the skills of one person complementing those of coworkers (or fellow crew members, squad mates, and so forth). In this context, averaging the productivity improvements arising from individual experience gains may not yield an accurate measure of capability improvement for the unit. Unit performance may be determined more by the weakest link--the inexperienced tank driver, for example, whose erratic movements offset any advantage of experience in the gunner's position. At a larger level, the weak link could be a specialty in which experience yields few rewards, and whose members play a key role in the operation of a unit comprising personnel in many specialties. The converse is also possible, however: greater experience in a few key positions may dramatically improve a unit's performance. 19/

Considerations of unit versus individual performance suggest that analyses of unit performance would be more appropriate sources of data for this study than the individual-performance analyses actually used. Unfortunately, usable examinations of unit performance are not available. 20/ Lacking them, this study implicitly assumed that the two tendencies described in the previous paragraph, to the extent they operate, exactly offset one another in determining the aggregate capabilities of the services' enlisted forces. 21/

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19. One study described the phenomenon thus: "For some interactive tasks, there is a 'bottleneck' effect, where performance is more determined by the least-able member, while for other tasks, there is an opposite effect, where the most-able member predominates and determines performance." See James P. Kahan and others, *Individual Characteristics and Unit Performance: A Review of Research and Methods* (Santa Monica, Calif.: The RAND Corporation, R-3194-MIL, February 1985), p. vi. The study distinguished "coactive" tasks, "in which group productivity is a function of separate, albeit coordinated, individual efforts" (p. v); and "interactive" environments requiring collaborative efforts. It concluded that individual abilities more strongly determine unit performance in coactive tasks than in interactive, and noted that interactive tasks predominate in the Army.

20. The CNA analysis of ship condition, described above, did examine unit performance, but although it provides qualitative support for the main conclusions of this chapter the report on this work does not give useful quantitative results. The study also did not examine the contribution of the various systems aboard a ship to the ship's ability to fight.

21. Interactions between officer and enlisted personnel undoubtedly are also important in determining a service's capabilities. This study ignores these interactions.

Relative Productivity Estimates and the Experience Mix

The analysis of the post-first-term data from the Air Force study highlights the dependence of relative productivity estimates on the particular experience mix available. A unit that was very lean in senior personnel would be forced to assign even complex tasks to inexperienced personnel. In such a unit, an additional experienced NCO might be able to replace two junior people by taking over tasks (such as periodic inspection--see Figure 5 above) in which completion times drop rapidly with experience. In a unit rich in experience, however, an added senior person would be forced to perform tasks that someone more junior could complete almost as quickly (corrosion control, for example).

Despite the substantial change in the enlisted experience mix of the Air Force that has occurred since 1979, when RAND conducted the study of AGE maintenance personnel, adjusting for that change had little effect on the productivity estimates derived from the data. 22/ Although this finding does not necessarily imply that relative productivities would not be affected by the seniority growth projected for the future, it does suggest that the effects should not be large.

Other Limiting Factors

A number of factors could limit the services' abilities to achieve all of the returns to more senior forces that are implied by the productivity indexes developed in this study. Some examples follow.

Hardware Dictates Numbers. In many military units the substitution of experience for numbers may be difficult, if not impossible. The maintenance platoon for a tank battalion probably could get along with fewer people if it was given more experienced personnel. An individual tank could not. The current main battle tank (the M-1 "Abrams") was designed around a crew of four; any smaller number would severely impair its ability to fight. Similar situations arise in other Army units, aboard Navy ships, and in the aircraft of all the services--indeed, in civilian factories as well. Past decisions about the design of machinery and other systems may fix absolutely the numbers of people needed to operate them.

The importance of hardware-dictated requirements can be overstated, at least in the long run. Although an individual tank may require four people regardless of their experience, greater experience throughout a tank battal-

22. Appendix B discusses the sensitivity test in greater detail.

ion might improve the battalion's performance enough to justify reducing the number of tanks in the unit. In addition, new tanks might be designed with more capable crews in mind. Ships would seem to be the epitome of long-lived hardware, but individual systems within a ship may be modernized many times during the ship's operational lifetime, allowing adjustments to be made for more capable crews. In short, the limitations imposed by past hardware decisions will tend to disappear with time, both because of new equipment and because organizational restructuring may prove appropriate.

Small Numbers. In an aircraft maintenance shop of fifty men and women, a 10 percent reduction means dropping five positions. For the three-person night shift, which is staffed in case repairs cannot wait until the morning, the 10 percent reduction probably means no decrease at all. Three people could be the minimum number needed to bring to the job all required skills, or to perform all the tasks likely to be required of them simultaneously.

To the extent that manpower requirements in work centers or other basic organizational units are dictated by sub-units of small size, the success of any attempt to substitute experience for numbers will be limited. This is not to say that there are no solutions to problems of this sort; two maintenance shops might be combined, for example. It does suggest, however, that the productivity indexes developed in this study may overstate the potential for exploiting productivity gains to reduce personnel strengths. The extent of this overstatement cannot be estimated without a much more detailed examination of requirements than was possible for this study.

Response of the Manpower System. The very phrase "manpower requirements" suggests a certain inflexibility of the services' manpower systems. 23/ Requirements are determined through a bottom-up process. At its base, work-center requirements describe the one best way to accomplish the required tasks. These are aggregated upward to specialtywide and ultimately servicewide requirements--in numbers and skill levels (or grades). Practical considerations--including supply constraints--may lead to modifications at various levels in the process, or to deviations between available inventories and stated requirements, but the process does not provide alternatives to the one best aggregate manning structure. 24/

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23. The term "requirements" as used here blurs the formal distinction between requirements and authorizations.

24. This broad outline focuses on one key aspect of the services' requirements determination processes. For a more complete description, see Department of Defense, *Manpower Requirements Report for Fiscal Year 1988*, Appendix D (February 1987). The General Accounting Office has assessed the rigor of various portions of the processes; a summary is provided in *DoD Manpower: Information on the Accuracy of Defense Manpower Requirements* (March 1986).

Because they do not identify alternative manning structures, the services' requirements systems cannot promptly identify personnel savings when more experienced NCOs are available, nor can they ensure the best use of greater experience. They can indicate changes in requirements after more experienced personnel are in place, but this can mean lags of several years because requirements are not reviewed frequently. These points are not intended as an indictment of the services' manpower requirements systems. Indeed, those systems appear to be more rigorously developed than is typical in the private sector. They are well suited to a situation in which enhancements in productivity come primarily from improvements in hardware; they do less well when the character of the manpower inputs changes.

The inflexibility of the services' manpower systems that derive from the requirements-determination process means that improvements in aggregate productivity may not come as quickly, or as completely, as this study's projections indicate. How important these effects will be is impossible to predict.

CONCLUSIONS

The data underlying this study's productivity indexes--the only information available--are limited, somewhat old, and not ideally suited to the task to which they have been applied. Considerations of these defects lead to no firm conclusions about whether the two main sets of productivity indexes, Case 1 and Case 2, overstate or understate the true aggregate returns to experience in the military. On balance, it appears that overstatement is more likely, at least for the Case 1 indexes. This conclusion is based primarily on the difficulty that the services' manpower systems might have in fully exploiting the potential gains from a more senior force, and on the problem of small numbers of personnel in some work centers. In combination with the earlier conclusion that Case 2 represents a very conservative interpretation of the available data, this suggests that it may be appropriate to take the Case 1 and Case 2 projections as upper and lower bounds, respectively, of future changes in aggregate productivities.

Clearly, the long list of limitations argues for more research. Most needed are studies examining the effects of experience beyond the first term of service. The limitations also suggest that one must be conservative in reaching any conclusions. This paper adheres to that philosophy by showing results under cases that assume little or no increase in productivity along with those that assume more substantial increases.

The list of limitations could also lead one to decide that no conclusions can be reached. The services seem to be planning, however, to accept substantial increases in experience that will add as much as $720 million per year to their personnel costs by 1992. They apparently feel they have information regarding trade-offs between experience and productivity that enables them to make this decision. Thus it seems reasonable to review alternatives to their decision using the same information. This is done in the next chapter.

CHAPTER IV

AGGREGATE PRODUCTIVITY LEVELS AND ENLISTED STRENGTH PLANS

Personnel strength levels are convenient, but deceiving, indicators of military force capabilities. Chapter II showed that the enlisted forces of all four active services will likely undergo fundamental changes through the mid-1990s, becoming composed increasingly of senior, experienced personnel. These more experienced personnel will add significantly to personnel costs--at least $420 million in 1992, relative to 1987, and as much as $720 million if they are promoted at the same rates as in the 1980s. Added costs will be even greater in subsequent years. A focus on personnel strengths alone ignores these important changes.

Weighting personnel at different experience levels by their relative productivities, rather than simply adding up their numbers, yields an alternative measure of capability that attempts to capture the effects of projected seniority growth. Available data are not adequate to permit firm conclusions about the rate at which productivity grows with experience, or about how individual productivities affect unit capabilities. The data are sufficient, however, to yield useful indications.

If the services are not taking account of productivity gains, they may be overestimating their future needs for enlisted personnel. Put another way, if the Congress is satisfied that the capabilities of today's enlisted forces are adequate, given their sizes, it can reasonably consider strength reductions, or increases smaller than requested, as the enlisted forces become more experienced.

This chapter examines the magnitudes of strength reductions or smaller increases--and their associated cost savings--that could be made without sacrificing overall capabilities. The next section sets out the main assumptions behind this examination and describes the basic procedure followed. The section following shows the capability-adjusted strength levels and costs, which depend upon which set of productivity indexes (Case 1, 2, or 3) is used. The final section summarizes the principal findings of this study.

ASSUMPTIONS AND PROCEDURE

This study derived alternative strength profiles for each service that yield profiles of aggregate personnel productivity matching the planned strength profile for that service. The Army, for example, plans for essentially constant enlisted strength levels through 1992; the reduced strength levels shown in the next section would keep aggregate productivity in the Army constant at its 1987 level. The Navy plans to increase enlisted strength by 5.3 percent between 1987 and 1992; the alternative below would yield roughly a 5.3 percent increase in aggregate productivity. In these alternatives, projected experience growth provides the required capability levels despite reductions, or smaller-than-requested increases, in personnel strength levels.

Three key assumptions underlie this procedure:

- The services' enlisted strength plans represent requirements for aggregate personnel capabilities.
- Enlisted productivity levels in 1987 constitute valid base levels relative to which to fix capabilities into the future.
- Experience can substitute for numbers.

The first assumption implies that the services do not take account of experience growth in setting enlisted strength requirements. Although this may seem rather extreme, the Defense Department's formal statement of manpower needs contains little indication to the contrary. 1/ Only the Navy expresses dissatisfaction with current experience levels or indicates that it plans to expand its career force significantly. 2/ The Army, in contrast, states: "The data ... indicate that the Army has a seasoned leadership cadre. No significant changes are projected." 3/ None of the service statements suggests that its strength request would be higher if seniority growth were not expected.

It should be noted that service strength plans have been sharply cut back in recent years. In 1984, for example, the Navy requested a 1986

1. Department of Defense, *Manpower Requirements Report for Fiscal Year 1988* (February 1987).
2. Ibid., p. IV-8, IV-9, IV-17.
3. Ibid., p. III-13.

strength of 595,600; a year later, its request for 1986 was 586,300. Army requests were reduced by 3,000 between 1982 and 1987. Although reductions in planned forces, and transfers of missions to the reserve components, explain much of the strength cuts, it is possible that improved productivity has also figured in. If improved productivity has been important, however, the services have not shown its importance by providing specific examples of large reductions in personnel linked to changes in personnel productivity.

The second assumption arbitrarily fixes as the base the last year, at the time of this study, for which the Congress had approved a defense budget. As shown in Chapter II, experience levels in 1987 were substantially above those in 1985, the last year before cuts under the Balanced Budget Act of 1985 began affecting defense appropriations. Thus, 1987 is a very good year, by historical standards, for military personnel capabilities.

The final assumption--that experience can substitute for numbers--was implicit in the analysis of the previous chapter, but several of the limitations and qualifications listed at the end of the last chapter raise concerns about its validity. The question is not so much whether substitution is possible at all, however, as it is the extent to which such substitution can reduce total requirements. Thus, although the assumption probably is valid, it may be appropriate to rely on the range of results bounded by Cases 1 and 2.

ENLISTED STRENGTHS AND COSTS

The alternative strength profiles through 1994, some of which show substantial cuts, are described below. The corresponding cost estimates follow the discussion of strength levels; relative to service plans, possible savings exceed $1 billion per year. Discussion of a potential side benefit--reduced accession requirements--concludes this section.

Productivity-Adjusted Alternatives for Enlisted Strengths

Limiting aggregate productivity increases to the percentage increases in planned strength levels could reduce the services' total 1992 enlisted strength below its level in 1987 (see Table 7). If experience adds considerably to productivity (Case 1), strength could be reduced by almost 30,000. More modest effects of experience on productivity (Case 2) would still justify a reduction of 12,000. Only in the unlikely event that an enlistee's experience beyond the first term adds nothing to his or her productivity (Case 3) would an increase in strength be necessary.

Personnel strength levels would drop even under the extreme assumption of Case 3 were it not for the Navy's current plan to increase its strength by 5.3 percent. Under Case 3, achieving a 5.3 percent gain in capability would require increasing Navy strength by 3.2 percent, less than planned but enough to outweigh the strength reductions in the other services.

TABLE 7. PERSONNEL STRENGTHS, PRESENT AND PLANNED, WITH ALTERNATIVES UNDER THREE PRODUCTIVITY CASES

	Army	Navy	Marine Corps	Air Force	Total
Enlisted Strengths (In thousands)					
1987	666	509	179	493	1,848
1992:					
Service Plan	667	536	183	486	1,871
Case 1	658	513	173	475	1,819
Case 2	662	518	176	480	1,836
Case 3	665	525	179	484	1,853
Percent Changes					
Relative to 1987:					
Service Plan	0.0	5.3	1.8	-1.4	1.3
Case 1	-1.3	0.8	-3.4	-3.6	-1.6
Case 2	-0.7	1.8	-1.7	-2.7	-0.7
Case 3	-0.2	3.2	0.0	-1.8	0.3
Relative to 1992 Service Plan:					
Case 1	-1.4	-4.3	-5.1	-2.3	-2.8
Case 2	-0.8	-3.4	-3.5	-1.3	-1.9
Case 3	-0.2	-2.1	-1.8	-0.5	-1.0

SOURCE: Department of Defense (1987 and service plans) and Congressional Budget Office.

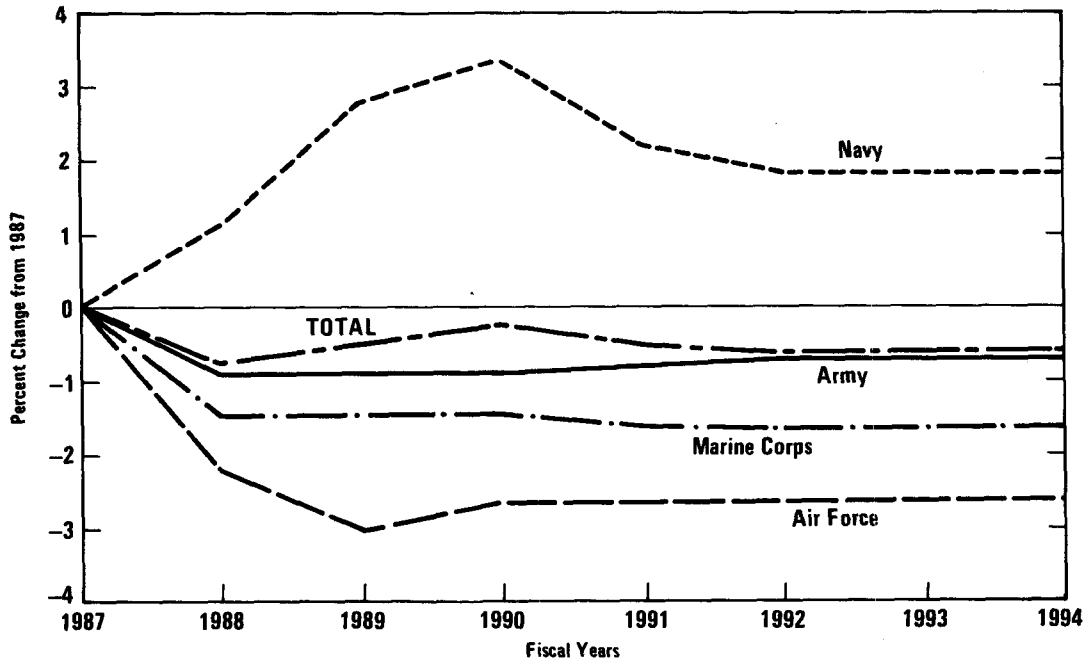
NOTE: Strength levels may not add to totals because of rounding.

Changes also can be assessed against service plans, rather than against the 1987 levels. Navy strength would be 2.1 percent to 4.3 percent below its plan for 1992, Marine Corps strength 1.8 percent to 5.1 percent below its plan. These large reductions reflect the substantial experience gains that this study projects for these two services. Reductions for the Army and Air Force are more modest, leading to total reductions for all services ranging from 1.0 percent to 2.8 percent. This would still amount to a reduction below planned levels of between 18,000 persons (Case 3) and 52,000 (Case 1).

In general, the largest cuts in enlisted strengths under the three alternatives would come in 1988. This is apparent in Figure 8, for Case 2. It reflects the lagged effect of strength changes on aggregate productivity when all of the cuts are made in accessions, as this study assumes they would be (see Chapter II). New recruits add little to total productivity; only after several years do the smaller numbers in the 1988 enlistment cohort have a significant effect--hence the offsetting upturns in Army and Air Force strength levels in 1990.

Figure 8.

Changes in Enlisted Strength Levels from 1987: Case 2



SOURCE: Congressional Budget Office.

Personnel Cost Savings under the Alternatives for Enlisted Strengths

Over the five years 1988 to 1992, the strength cuts under Case 1 would save a total of $3.6 billion in 1987 dollars relative to costs under the services' strength plans, an average of more than $700 million per year. Case 2 cuts

TABLE 8. PERSONNEL COSTS, PRESENT AND PROJECTED, WITH ALTERNATIVES UNDER THREE PRODUCTIVITY CASES

	Army	Navy	Marine Corps	Air Force	Total
			Personnel Costs (In billions of 1987 dollars)		
1987	17.6	13.9	4.4	13.6	49.5
1992:					
Service Plan	18.3	15.2	4.8	13.9	52.2
Case 1	18.1	14.8	4.6	13.6	51.0
Case 2	18.2	14.9	4.6	13.7	51.4
Case 3	18.2	15.0	4.7	13.8	51.8
			Percent Changes		
Relative to 1987:					
Service Plan	3.8	9.6	7.9	2.2	5.3
Case 1	2.6	6.3	3.5	0.2	3.0
Case 2	3.1	7.1	5.0	1.0	3.8
Case 3	3.5	8.2	6.5	1.7	4.6
Relative to 1992 Service Plan:					
Case 1	-1.2	-3.0	-4.1	-2.0	-2.2
Case 2	-0.7	-2.3	-2.7	-1.2	-1.5
Case 3	-0.2	-1.3	-1.3	-0.4	-0.7

SOURCE: Congressional Budget Office.

NOTE: Cost figures may not add to totals because of rounding.

would save $2.2 billion, and even the modest cuts under Case 3 would save $1.0 billion. Table 8 shows the 1992 savings in more detail. 4/

Personnel costs will rise in real terms between 1987 and 1992 under even the most severe alternative for strength cuts (Case 1). The Case 1 cuts would limit the cost increase to $1.5 billion, however--a little more than half the increase that would occur if the services' strength plans were carried out. Costs rise even when strength levels are cut because real pay levels must grow if private-sector pay increases are to be matched and, to a esser extent, because of seniority growth. As shown in Chapter II, seniority growth will add at least $420 million, and possibly as much as $720 million, to 1992 costs.

The savings are evident when the costs of the three alternatives are compared with the costs under the services' strength plans (bottom panel, Table 8). 5/ Under Case 1, 1992 savings would range from 1.2 percent for the Army to 4.1 percent for the Marine Corps, with a 2.2 percent saving overall. That 2.2 percent amounts to $1.2 billion, with the Navy alone accounting for almost $500 million. The Case 2 savings--1.5 percent overall--would be nearly $800 million. To put these savings in perspective, the Case 1 strength cuts would reduce 1992 defense costs by nearly as much as cutting two percentage points off the 1988 military pay raise, a cut that would reduce the pay of officers as well as enlistees. 6/

Accession Requirements

A side benefit of strength reductions would be an easing of recruiting pressures, which some have seen as a serious concern in the 1990s. Although accession requirements would fall only slightly in the long run, large reductions would occur in the years in which the strength cuts were made and again when the smaller entry cohorts reached reenlistment points. Thus, strength cuts could be timed to ease recruiting difficulties, should they arise.

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4. The cost savings were projected under the assumption that richer grade mixes would be permitted (see Chapter II). Savings are virtually identical, however, under the alternative assumption of no changes in aggregate grade mixes.

5. Measured relative to the CBO baseline projections of the federal budget, savings would fall between those measured relative to 1987 and those measured relative to the service plans.

6. Congressional Budget Office, *Reducing the Deficit: Spending and Revenue Options* (January 1987), pp. 59-60.

To give a specific example, the cuts under Case 2 would reduce the total requirement for nonprior-service (NPS) accessions by 4.7 percent in 1988 and by 6.5 percent in 1991, relative to requirements under the services' strength plans. By service, reductions in 1988 would range from zero percent for the Navy (16.5 percent in 1991) to 8.8 percent for the Marine Corps. Total NPS requirements over the five years 1988 through 1992 would fall by 3.6 percent. Reductions of this magnitude would not completely offset the effects of smaller enlistment-age cohorts in the 1990s, but could be of significant help if problems arose with the quality of recruits.

CONCLUSIONS

The alternatives presented in the previous section should not be construed as recommendations for strength reductions, either from current levels or from levels planned for the future. Rather, they should be taken as indications of the magnitudes of reductions that might be justified following a more complete examination of experience/productivity trade-offs in the military. The data underlying this study are too limited to provide a firm basis for decisions on enlisted strength levels. Nonetheless, the main strength-level alternatives--Case 1 and Case 2--are based on the best information currently available, and so should not be completely discounted. Particularly noteworthy are the possible cost savings if aggregate productivity levels were used to set enlisted strength levels, rather than the reverse as is now implicitly done.

The results of this study should present a challenge to those who would permit or encourage the experience trends in the enlisted forces without any formal justification of the need for more seniority. Either they must accept that experience does enhance productivity, in which case strength cuts should be possible, perhaps along the lines of the Case 2 alternative above; or they can reject this implication and, by extension, reject the need for greater seniority. Tightened reenlistment standards, possibly accompanied by severance payments to the more senior personnel forced out, could limit the coming shifts. Cost savings on the order of $500 million in 1992 should be possible if seniority growth were halted.

Acceptance of this study's productivity results need not necessarily mean acquiesence to personnel strength reductions. It could be argued that, however real the productivity gains accruing from more experienced personnel, those gains cannot be translated into improvements in aggregate capability that could be traded off against numbers. Some support for this view appears in the limitations identified at the end of Chapter III. Even if the

possibility of trading experience for numbers is granted, seniority growth appears to provide significant improvement in defense capability at fairly modest cost. If this study's results are used to justify the projected seniority growth, however, the costs and benefits must be compared with those of alternative means for improving capabilities, and of programs that might be sacrificed to pay for greater experience in the enlisted force.

The coming seniority growth, like that of the last decade, is a natural consequence of the switch to a wholly volunteer military. It can be exploited to improve defense capability or to ease the effects of defense budget cuts or slower growth; or its effects on productivity and costs can be ignored, as has largely been the case in the past. This study should serve to bring these alternatives under closer scrutiny.

APPENDIXES

APPENDIX A

PAY AND UNEMPLOYMENT ELASTICITIES

TABLE A-1. ASSUMPTIONS FOR PAY AND UNEMPLOYMENT ELASTICITIES, BY SERVICE AND YEAR OF SERVICE

	Pay Elasticity				Unemployment Elasticity			
Year of Service	Army	Navy	Marine Corps	Air Force	Army	Navy	Marine Corps	Air Force
1	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
2	2.8	0.0	0.0	0.0	0.61	0.00	0.00	0.00
3	2.4	2.5	2.8	0.0	0.50	0.51	0.54	0.00
4	2.2	2.5	2.8	2.1	0.45	0.50	0.51	0.44
5	1.8	2.4	2.6	1.9	0.36	0.46	0.46	0.37
6	1.7	2.8	1.7	1.8	0.32	0.42	0.28	0.35
7	1.6	1.7	1.5	1.6	0.30	0.31	0.26	0.29
8	1.3	1.4	1.5	1.4	0.22	0.25	0.23	0.26
9	1.1	1.2	1.5	1.3	0.19	0.20	0.22	0.22
10	1.0	1.1	1.4	1.2	0.16	0.18	0.20	0.20
11	0.9	1.0	1.2	0.8	0.14	0.15	0.16	0.12
12	0.8	0.8	0.8	0.5	0.12	0.12	0.10	0.07
13	0.7	0.5	0.8	0.5	0.10	0.07	0.10	0.06
14	0.5	0.4	0.5	0.4	0.07	0.05	0.06	0.05
15	0.5	0.3	0.5	0.2	0.06	0.03	0.05	0.03
16	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
17	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
18	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00
19	0.0	0.5	0.0	0.0	0.00	0.10	0.00	0.00
20	2.5	2.8	2.6	2.2	0.33	0.34	0.30	0.27
21	2.4	1.9	2.1	2.1	0.29	0.26	0.26	0.27
22+	0.0	0.0	0.0	0.0	0.00	0.00	0.00	0.00

SOURCE: Congressional Budget Office.

NOTE: These elasticities indicate the percentage change in the reenlistment rate at the given year of service resulting from a 1 percent change in the variable.

APPENDIX B

DEVELOPMENT OF PRODUCTIVITY INDEXES FROM THE RAND AIR FORCE STUDY

The Air Force study did not produce a final report; the only published information on its findings appears in the text of a briefing. 1/ At CBO's request, the Air Force provided the data developed in the study, as well as a complete description of the study's methodology. The description, prepared by the study's principal investigator, included a number of cautions, to which the Air Force added several others; the cautions are detailed at the end of this appendix.

Data

The study divided the manpower in Aerospace Ground Equipment (AGE) maintenance into six labor types based on pay grade and skill level (an Air Force measure of proficiency). Labor-type 1, for example, consisted of all personnel in pay grades E-1 through E-3, and labor-type 4 of those in grade E-5 and with skill level 5 (the middle of three skill levels). On average, AGE personnel in labor-type 3 had completed four years of service, making this a useful reference group for computing relative productivities.

The data provided to CBO were of four general types:

- Estimates of productivities by labor type, relative to the productivity for labor-type 3, for each of 13 AGE maintenance tasks. 2/
- Estimates of "check time" by labor type and task; check time is the amount of time required for instruction/supervision/checking of one hour's work.

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1. S. Craig Moore, *Demand and Supply Integration for Air Force Enlisted Work Force Planning: A Briefing* (Santa Monica, Calif.: The RAND Corporation, N-1724-AF, August 1981).

2. For brevity, this discussion refers to "tasks." In fact, each "task" comprised a group of tasks that were selected to be fairly homogeneous with respect to the types of workers who do them, the degree to which their performance improves with experience, and their changes in workloads over time. The groups generally contain about 8 to 25 tasks.

- Information on monthly workloads by task.
- Information on the constraints in the task-assignment problem that were developed in the study.

Relative Productivities by Task and Labor Type. Productivity estimates were provided by 24 AGE maintenance supervisors who evaluated 90 individual technicians working at two Air Force bases. Together, the 13 tasks for which the data were sufficient, two of them supervisory, accounted for abut 75 percent of the work time of the AGE technicians; for the remaining 13 tasks performed in AGE maintenance, the data were too few for reliable estimates. Relative productivities differed greatly across the tasks. At one extreme, type-6 labor was 90 percent more productive than type-3 on one task, whereas on another task the two labor types were equally productive.

Check Time. Except in the simplest task, work by any labor type except type 6 generated a check-time requirement. For type 1, the check times averaged about 0.13 hours per hour worked across the 11 nonsupervisory tasks; for type 3, the average was about 0.06 hours. Even type-6 labor generated check-time requirements in four of the tasks, including both of the supervisory tasks.

Workloads. Separate monthly workloads, in hours, were provided for the nonsupervisory tasks at each of the two bases. These workloads differed substantially between the two bases, both in their totals and in their distributions across tasks. Workloads for the two supervisory tasks were generated by the check-time requirements for the other 11 tasks.

A specific example of the data appears below, showing the productivity, check-time, and workload data for one of the tasks. The top line shows the relative productivities; the entry for labor type 3 is 1.0 because that is the reference group. On this task, type-1 personnel are roughly 28 percent less productive, and type-6 personnel 41 percent more productive, than personnel of type 3. The last two columns give the monthly workloads at the two bases examined: 179 hours of type-3 labor or its equivalent at Norton AFB and 117 hours at March AFB. Finally, the bottom line shows the check times. For every hour that a type-3 person works on this task, for example, someone of a higher labor type must spend 0.098 hours (about six minutes) supervising, instructing, and checking the work.

	Labor Type						Requirements at AFBs	
	1	2	3	4	5	6	Norton	March
Relative Productivity	0.719	0.836	1.000	1.108	1.242	1.413	178.7	116.7
Check Time	0.155	0.131	0.098	0.068	0.031			

Constraints. The materials provided identified four sets of constraints that affect the allocation of labor types across tasks: workload constraints, forcing the workload requirements to be met; work-mix constraints, to ensure an appropriate mix of tasks for the personnel of each labor type; available time constraints, which specify the monthly hours per worker; and manning mix constraints, giving an upper and lower bound for the percentage of the work force in each labor type. 3/ Also provided were the actual percentages of AGE maintenance personnel in each labor type throughout the Air Force at the time of the study. As discussed below, this study used the latter figures, rather than the bounds identified in the manning mix constraints, to fix the distribution of labor types.

Methodology

The goal of this analysis is to determine relative productivities by labor type for the entire AGE maintenance work force. As noted in Chapter III, simply averaging across the 13 tasks would not be appropriate; no rational manager facing limited resources would assign the same mix of tasks to every person, as averaging implies. Instead, this study derived aggregate relative productivities after first determining the optimal assignments of personnel to tasks.

Optimality. Relative productivities are dependent on the labor-type mix of the available personnel (see below). Fixing the mix at the percentages

3. The present study did not apply the available-time constraints because they merely represented the conversion from numbers of hours to numbers of people.

among all AGE maintenance personnel created a plausible measure of optimality: the fewer personnel required, the better the task assignments. With the mix across labor types fixed (for example, two type-1s for every type-3), minimizing the number of type-3s yields the same result as minimizing the total. Choosing to minimize type-3 labor means that all the productivities will be measured relative to this group, which with an average of four years of service is the same reference group used in the EUS.

An Example

The complete assignment problem is too complex to present here, involving well over 100 equations representing the various constraints. Rather than describe the problem in generalities, this section presents a simplified example with only two labor types and three tasks. The three tasks are denoted SI (simple), CO (complex), and SU (supervisory); the two labor types are 3 and 6. Hypothetical data for the three tasks appear below.

	Labor Type		
Task	3	6	Workload
Simple (SI)			
Relative productivity	1.00	1.25	400.00
Check time	0.08	0.00	
Complex (CO)			
Relative productivity	1.00	1.60	300.00
Check time	0.11	0.04	
Supervisory (SU)			
Relative productivity	1.00	1.30	
Check time	0.06	0.04	

The task assignments are indicated by variables such as SI3, which measures the hours of type-3 labor assigned to tasks SI. Similarly, SU6 denotes the number of hours that type-6 personnel devote to the supervisory task. The following equations state the problem:

Minimize: SI3 + CO3 + SU3

Subject to:

$$1.00 \times SI3 + 1.25 \times SI6 \geq 400.00$$
$$1.00 \times CO3 + 1.60 \times CO6 \geq 300.00 \qquad \text{(Workload constraints)}$$

$$0.08 \times SI3 + 0.11 \times CO3 + 0.04 \times CO6 + 0.04 \times SU6 \leq 1.30 \times SU \qquad \text{(Check-time constraint)}$$

$$SI3 \geq 0.3 \times (SI3 + CO3 + SU3)$$
$$SI3 \leq 0.8 \times (SI3 + CO3 + SU3)$$
$$CO3 \geq 0.2 \times (SI3 + CO3 + SU3)$$
$$CO3 \leq 0.4 \times (SI3 + CO3 + SU3)$$
$$SI6 \leq 0.2 \times (SI6 + CO6 + SU6)$$
$$CO6 \geq 0.2 \times (SI6 + CO6 + SU6)$$
$$CO6 \leq 0.9 \times (SI6 + CO6 + SU6)$$
$$SU6 \geq 0.3 \times (SI6 + CO6 + SU6)$$
$$SU6 \leq 0.6 \times (SI6 + CO6 + SU6) \qquad \text{(Work-mix constraints)}$$

$$SI6 + CO6 + SU6 = 0.5 \times (SI3 + CO3 + SU3) \qquad \text{(Labor-type constraint)}$$

The first two equations, which ensure that the required work is accomplished, demonstrate that all requirements for hours of work are expressed in terms of type-3 labor. The time inputs of type-6 labor, SI6 and CO6, are multiplied by the relative productivities for this group in the two tasks (see above). If all the CO work was done by type-6 labor, for example, only 187.5 hours would be required (300 ÷ 1.6).

The third equation (check-time constraint), adds up the check time generated by each of the tasks. Note that type-6 labor in the SI task generates no check time. The equation expresses another limitation imposed in the original study: check time must be performed by a higher labor type than that which generated it, except for type-6. This is why there is no equation for check time performed by type-3 labor, and no entry for SU3 in the single check-time equation.

The large group of work-mix constraints impose reasonable limits on the distribution of time across tasks for each labor type. The first two equations, for example, say that between 30 percent and 80 percent of type-

3 hours must be devoted to the SI task. The second two require that between 20 percent and 40 percent of type-3 hours be spent on the CO task. Because these are the only two tasks open to type-3 labor in this example, the two sets of equations could be combined into one. In the full problem, however, the 13 tasks are divided into four categories, with the constraints applied to each category as a whole rather than to individual tasks. The bounds in the full problem were determined as part of the original study, based on an examination of task workloads among the individuals in each labor type.

The fifth work-mix equation stands alone (no "greater than or equal") because all of the variables in the problem must be positive. Thus, between 0 percent and 20 percent of type-6 hours must be spent on task SI.

Finally, the last equation requires that there be twice as many people in labor-type 3 as in type 6. In the full problem, the mix is fixed across labor types at the distribution within the AGE maintenance specialty that existed when the original study was conducted.

Numerical Results. The following values solve the example problem:

SI3 = 364.13
SI6 = 28.70
CO3 = 91.03
CO6 = 130.60
SU6 = 68.27

Only five constraints are binding: the two workload constraints, the lower limits on CO3 and SU6, and the labor-type constraint. Note that the check-time constraint is not binding; the amount of supervision time is driven by the imposed lower limit, not by the task-generated check time. The same situation arose in the full problem.

To determine the relative productivity of type-6 labor, the problem is solved again with the labor-type constraint replaced by a constraint that the total type-6 hours be less than or equal to the total in the first solution (227.58, equal to SI6+CO6+SU6). This does not change any of the values above because meeting the workload constraints still requires 455.16 type-3 hours (twice the type-6). The new constraint is binding, and the shadow price associated with it is the negative of the relative productivity of type-6 labor. Recall that a shadow price measures the effect on the objective function if the constraint is relaxed by one unit. In this case, relaxing the constraint means adding one type-6 hour; the shadow price indicates that type-3 hours could be reduced by 0.92 hours.

This result is certainly counterintuitive, indicating that type-6 labor is less productive than type-3 at the margin. The reason it obtains is that the binding lower limit on type-6 supervision time forces every type-6 worker, including the marginal worker, to devote 30 percent of his or her time to work that, within the problem, is nonproductive. This is not to say that the lower limit makes no sense; it captures the requirement for supervisory work that is not task-related, such as writing performance evaluations and counseling junior personnel. The difficulty is that it is unreasonable to assume that when a senior person replaces some number of junior personnel the total supervision requirement would increase.

A more plausible estimate of the relative productivity of type-6 personnel is obtained when the total for hours of supervisory work (SU6 in this example) is fixed at its value in the first solution. 4/ With this done, the relative productivity of type-6 personnel is 1.31.

The Full Problem

Despite the simplicity of the example, it demonstrates all the essential elements of the full problem. Although the initial estimate of type-6 relative productivity in the full problem was not less than one, it was less than the estimate for type-5 personnel. The constraints setting lower limits on supervision time by labor of types 3 through 6 (types 1 and 2 could not supervise) were all binding. Replacing those constraints, which are expressed in percentage terms, with constraints fixing the absolute hours of supervision by each labor type changes an implausible downward-turning experience/productivity profile into a more reasonable one that rises with each step upward through the labor types.

To derive the Case 1 productivity index from the labor-type productivities, this study assumed that the estimate for a given labor type would be the productivity of someone with the average years of service of personnel in that labor type. Type-3 personnel, for example, had an average of about 4 years of service, type-6 an average of about 16.5. Linear interpolation between successive points gave intermediate values.

Sensitivity to the Experience Mix. Between 1979 and 1985, the distribution of enlisted personnel in the Air Force changed considerably. The percentage

4. That is, the lower-bound constraint on SU6 is replaced with a constraint that SU6 = 68.27.

of first-term personnel dropped by about six points, and that of personnel in years-of-service 5 through 10 rose by the same amount. If the AGE maintenance specialty experienced the same change, it would have meant roughly a six percentage-point shift from labor types 1 and 2 to types 4 and 5 (the type-3 percentage would not be strongly affected because type-3 includes both first- and second-term personnel). As noted in Chapter 3, this shift might be expected to affect the relative productivities derived from the AGE maintenance data. In fact, virtually all the effects are insignificant.

Little change occurred in the relative productivities because altering the mix of labor types only caused two changes in the sets of tasks to which the six labor types were assigned. The hours assigned changed, of course, but these changes alone cannot affect marginal productivities; in effect, they move the solution point along a flat portion of the production isoquant. The two alterations in task assignments, which affected labor types 3 and 6, increased the relative productivity of type-6 labor from 1.52 to 1.62. This rise seems anomalous, given that it was caused by increases in the percentages of type-4 and type-5 labor. It appears to result from somewhat unusual patterns of relative productivity within the two affected tasks. Presumably, the patterns are unusual because of the small sample size of the original survey.

Qualifications

In supplying the data, the study's principal investigator noted several cautions. For the most part, these concern the applicability of the study's methods--analysis of individual tasks and linear programming to examine alternative work forces--to the full range of Air Force occupational specialties. Whether they affect the usefulness of the estimated aggregate productivities is unclear.

One caution mentioned by the principal investigator clearly is relevant to the current study. He noted: "The AGE maintenance work center and the general accounting work centers were selected for this study because they showed clearcut promise for the substitutability of one within-specialty labor type for another, for substantial productivity increases with greater worker experience, and, consequently, for a wide range of alternative task allocations and corresponding multiplicity of manpower configurations that could handle the associated workloads." This suggests that substituting experience for numbers may be more feasible in this specialty than is true in other Air Force specialties, and that the relative productivities of senior personnel may be lower in other specialties. These issues are discussed in Chapter III.

The Air Force office that transmitted the data to CBO added further cautions. Of particular relevance to the current study, it noted that "the methodology requires arbitrary assumptions to establish the model's boundaries," and "type of equipment and workload mix vary significantly from base to base." Although the importance of the latter is difficult to assess, one set of constraints that might be classed as "arbitrary assumptions" played a major role in determining the results of CBO's analysis: the work-mix constraints. As noted above, the way in which the lower bounds on supervision time were entered into the problem directly affected the relative productivity estimates. Because of this, and reflecting a desire to be conservative, this study used a procedure that yielded relatively modest estimates of the returns to experience to derive the Case 1 indexes.

77-384 (80)