CR-242

Sustaining Volunteer Enlistments in the Decade Ahead: the Effect of Declining Population and Unemployment

Final Report

By

Daniel Huck
Jerry Allen

Assisted By

Kenneth Goudreau
Geraldine Sica
Jose Imperial
Kenneth Midlam

Contract No. MDA903-75-C-0204

September 1977

OPERATIONS ANALYSIS GROUP
GENERAL RESEARCH CORPORATION
A SUBSIDIARY OF FLOW GENERAL INC.
7655 Old Springhouse Road, McLean, Virginia 22102

Prepared For:

The Assistant Secretary of Defense
(Manpower, Reserve Affairs and Logistics)

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)* Sustaining Volunteer Enlistments in the Decade Ahead: The Effect of Declining Population and Unemployment

5. TYPE OF REPORT & PERIOD COVERED
CR 11/76-9/77

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Daniel F. Huck
Jerry Allen

8. CONTRACT OR GRANT NUMBER(s)
MDA903-75-C-0204

9. PERFORMING ORGANIZATION NAME AND ADDRESS
General Research Corporation
7655 Old Springhouse Road
McLean, Va. 22102

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS
The Assistant Secretary of Defense (M,RA&L)
The Pentagon

12. REPORT DATE
September 1977

13. NUMBER OF PAGES
110

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*

15. SECURITY CLASS. *(of this report)*
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

All-volunteer force, manpower planning, forecasting, quality enlistments, nonlinear regression analysis, econometric modeling

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The study was prompted by concern that the AVF faces serious manpower problems over the next decade. Specifically, four issues were addressed in the study:

o What effect, if any, will the projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?

(Continued on reverse side)

CONTENTS

CHAPTER		PAGE
1	EXECUTIVE SUMMARY	1-1
	Objectives of the Study	1-1
	Methodology Employed	1-1
	Supply Effects of the Model Parameters	1-5
	Enlistment Forecast Results	1-9
	Accession Budget Implications of the Enlistment Supply Forecasts	1-13
	Need for Additional Research	1-18
2	BACKGROUND AND PURPOSE	2-1
	Objectives of the Study	2-1
	Background Information Supporting the Rationale for the Study	2-1
3	METHODOLOGICAL CONSIDERATIONS IN DEVELOPING AN ENLISTMENT SUPPLY MODEL	3-1
	General	3-1
	The Supply Model	3-1
4	SUPPLY EFFECTS OF THE MODEL PARAMETERS	4-1
	General	4-1
	Supply Elasticities	4-1
	Discussion of Results	4-2
5	ENLISTMENT PROJECTIONS	5-1
	General	5-1
	Results	5-1
6	ACCESSION BUDGET IMPLICATIONS OF THE ENLISTMENT SUPPLY FORECASTS	6-1
	General	6-1
	Methodology	6-1
	Results from the Budget Model	6-4
APPENDIXES		
A.	Linearization Transformations for Least Squares Problems	A-1
B.	Source Data	B-1
C.	Correlation Matrices, Means and Standard Deviations of Variables Used in the Supply Models	C-1

FIGURES PAGE

1.1 Population of 17-21 Year Old Males 1-10
1.2 Accession Production Functions, NPS Male, DHSG, I-IIIA 1-14
1.3 Army Accession Production Functions NPS Male, DHSG, I-IIIA 1-15
2.1 Population of 17-21 Year Old Males 2-5
5.1 17-21-year-old QMA Male High-School Graduates Mental Group Distribution by Race 5-8
6.1 Accession Production Functions NPS Male, DHSG, I-IIIA 6-5
6.2 Army Accession Production Functions NPS Male, DHSG, I-IIIA 6-6

TABLES

1.1 Summary Enlistment/QMA Data 1-3
1.2 Finalized Supply Models for I-IIIA, DHSG Accessions 1-6
1.3 Non-Race-Specific Supply Models for I-IIIA DHSG Enlistments 1-7
1.4 Marginal Productivities of Service Recruiters for NPS Male, DHSG, I-IIIA Enlistments 1-7
1.5 General and 18-19 Year Male Unemployment Rates: Historical Trend and CBO Projections 1-11
1.6 Summary of I-IIIA DHSG Enlistment Projections Using the January '77 CBO Unemployment Projections 1-12
1.7 Change in Accession Budget to Overcome Projected Decline in NPS Male DHSG I-IIIA from CY 1975 Level 1-17
1.8 Projected Declines in Quality Accession Levels Under Alternative Assumptions Concerning Population Effects 1-19
2.1 Trends in Male Enlisted Attrition Rates During the First Two Years of Service 2-2
2.2 Trends in Diploma High-School Graduate Accessions Expressed as a Percent of NPS Enlistments 2-3
2.3 General and 18-19 Year Male Unemployment Rates: Historical Trend and CBO Projections 2-4
2.4 Percent Change in Male Population, 17-21 Years Old, by Race (Series II) 2-6
2.5 Male Population, 17-21 Years Old, by Race (Series II) 2-7
2.6 Distribution of the Top Ten States QMA I-IIIA Male HSG 17-21 Year Old 2-9
2.7 Number of High School Graduates Compared with Population 17-Year-Olds 2-10
2.8 Annual Percentage Change in Enrollments, Male and Female 2-11

TABLES (continued) PAGE

2.9 Percentage Distribution by Age for Male and Female DHSG Enlistees According to the May, 1975 AFEES Survey 2-12
2.10 Enrollment Status in Post-Secondary Education of the High-School Class of 1972 2-13
4.1 I-IIIA, DHSG Accession Supply Elasticities Arising from Log-Linear Model (L) and Multiplicative Model (M) 4-3
4.2 Finalized Supply Models for I-IIIA, DHSG Accessions 4-4
4.3 Summary of the Finalized Elasticities for Population and Recruiters by Race and Service 4-5
4.4 Non-Race-Specific Supply Models for I-IIIA DHSG Enlistments 4-10
5.1 Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions by Race and Service under October 76 Unemployment Projections 5-2
5.2 Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions by Race and Service under January 77 Unemployment Projection 5-3
5.3 Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions Due to Population by Race and Service 5-4
5.4 Recruiting Market Penetration 5-7
5.5 Projected I-IIIA, DHSG Accessions Under Projected Population and Unemployment Changes, by Race and Services for October 1976 and January 1977 Unemployment Projections 5-10
5.6 Summary Enlistment/QMA Data 5-11
5.7 Summary of I-IIIA DHSG Enlistment Projections Using the January '77 CBO Unemployment Projections 5-12
6.1 Accession Program Elasticities 6-2
6.2 Selected Accession Program Budgets Supporting CY 1975 Enlistment Supply Levels 6-3
6.3 Marginal Production Rates for Recruiters 6-4
6.4 Change in Accession Budget to Overcome Projected Decline in NPS Male DHSG I-IIIA from CY 1975 Level (Army) 6-7
6.5 Change in Accession Budget to Overcome Projected Decline in NPS Male DHSG I-IIIA from CY 1975 Level (Navy) 6-8
6.6 Change in Accession Budget to Overcome Projected Decline in NPS Male DHSG I-IIIA from CY 1975 Level (Marine Corps) 6-9
6.7 Change in Accession Budget to Overcome Projected Decline in NPS Male DHSG I-IIIA from CY 1975 Level (Air Force) 6-10

Chapter 1

EXECUTIVE SUMMARY

OBJECTIVES OF THE STUDY

This report was prepared for the Office Assistant Secretary of Defense, Manpower, Reserve Affairs & Logistics. The study was prompted by concern that the AVF faces serious manpower supply problems over the next decade. Specifically, four issues were addressed in the study:

- What effect, if any, will the projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?
- What will be the effect on the supply of quality enlistments if the economy continues to improve and the unemployment rate continues to decline?
- If the decline in quality enlistments is projected over the next decade, what additional recruiting resources will be required to offset this decline?
- What are the manpower policy implications of attempting to sustain the AVF in the face of potential shortages of quality volunteers?

METHODOLOGY EMPLOYED

The analysis consists principally of the development of an econometric model that relates numbers of accessions to several "explanatory" variables that are hypothesized to affect numbers of accessions. These relationships are then used to estimate future accession levels once future values of the explanatory variables have been projected or hypothesized. Finally, a sensitivity calculation is made to show how future accession levels can be affected by changes in those explanatory variables under the control of the Services.

Selection of the Variables to be Included in the Model

Based upon a host of other studies that have attempted to forecast enlistment supply and the desirability of empirically testing the effect of population on enlistments, the following five variables are included in the model.

- Quality enlistments. The dependent variable used in this analysis is the number of non-prior-service, male, diploma high-school graduates (DHSG) in the upper 50th percentile of the standardized mental test score distribution (mental categories I-IIIA). A fundamental assumption of the analysis and the rationale for the selection of this dependent variable is that this group is "supply-limited;" that is, the number of quality accessions is limited by the supply of such persons that can be induced to join the military, rather than by the military's demand. This assumption also implies that other qualified but less preferred groups are currently in excess supply and the Services can administratively control the number they desire to have enlist. These "demand constrained" groups include female high-school graduates; prior service personnel; male, mental-group IV, high-school graduates; and, to some extent, male, mental-group IIIB, high-school graduates. This latter group appears to be administratively controlled by the Air Force and the Navy and, to a lesser extent, by the Army and Marine Corps. A separate dependent variable was created for each Service as well as by race (white and non-white).

- Quality population. The first independent variable used in the model is the number of Qualified Military Availables (QMAs) that is contained in the relevant market recruited by the Services. The segment of the QMA market that was used in this analysis is the population of NPS, diploma high-school graduate, 17-21-year-old males, classified in mental categories I-IIIA, and not pursuing further schooling. Nationally, this subpopulation accounts for approximately 6 percent of the military available (MA) population. Both the enlistment and QMA counts were split by Service, mental group and race for male diploma graduates and are shown on Table 1.1.

- Recruiters on stations. The recruiter variable used in this analysis consists of estimates of production recruiters on station as of 31 October 1976. This was the only state level estimate of recruiter strengths available and it is presumed that the distribution of recruiters on this date is comparable to the average distribution during CY 1975. The fact that the recruiter variable entered in a large and statistically

Table 1.1

SUMMARY ENLISTMENT/QMA DATA

CY 1975

NPS Male Diploma Graduates

	White				Non-white				
	1,2	3A	3B	4	1,2	3A	3B	4	TOTAL
Army									
#	31,043	16,806	15,779	3,838	2,899	5,247	11,675	4,804	92,091
%	34	18	17	4	3	6	13	5	100
Navy									
#	30,334	17,797	11,176	2,921	1,742	2,376	2,744	1,031	70,121
%	43	25	16	4	3	3	4	2	100
USMC									
#	11,504	7,456	5,847	595	1,416	1,818	2,265	310	31,211
%	37	24	19	2	5	6	7	1	100
USAF									
#	24,528	15,303	9,863	463	1,704	2,681	2,728	95	57,365
%	42	27	17	1	3	5	5	a/	100
Total DOD									
#	97,409	57,362	42,665	7,817	7,761	12,122	19,412	6,240	250,788
%	39	23	17	3	3	5	8	2	100
QMA b/									
#	645,071	294,447	268,402	148,439	21,775	29,907	66,157	76,203	1,550,401
%	42	19	17	10	2	1	4	5	100

---

a/ Less than 0.5%.

b/ QMA includes QMA not in school, 15% of QMA in school because 15% of enlistees responded they were in school at time of enlistment on the May 1975 AFEES survey, and DOD enlistments for CY 1975.

significant manner for each of these Service- and race-specific models tends to confirm that the assumption concerning recruiter distributions was correct.

- Unemployment. The variable used in these models represents general unemployment as a percent of the labor force and was extracted from the Employment and Training Report of the President (1976).

- Civilian pay. In order to account for regional variation and economic attractiveness of military service as an alternative to civilian pursuits, a civilian pay variable was included in the model. The data for this variable were extracted from Table C.13, "Salaries and Earnings of Production Workers on Manufacturing Payrolls by State and Selected Areas," in the BLS report, Employment and Earnings for August 1976. Payroll data used in the model are for June 1976.

Selection of the Model

A cross-sectional model was selected, involving a single annual observation on each of the 50 states in the U.S. This form of a model, rather than a time series model, was selected to obtain a sufficient range of values for each of the variables (especially population) to permit accurate estimation of the statistical relationships among the variables. Without the cross-sectional dimension to the model, there would not have been enough variation in the population variable over time during the relatively short period since the beginning of the AVF. Once a cross-sectional model was selected, only one year's data could be used because, at the time of the analysis, data on recruiter allocation across geographical area were available for only a one-year period.

A multiplicative Cobb-Douglas form of model was selected because it would be least sensitive to possible inaccuracies in the source data.

Estimation of Model Parameters

Conventionally, parameters of a multiplicative Cobb-Douglas model are computed by converting the model into its companion log linear form and solving for the approximate elasticities using a standard linear regression package. This procedure was not employed in the present analysis because it was found to produce significantly erroneous results. Rather, an improved technique, called the Gauss-Marquardt least squares algorithm, was employed to obtain estimates not subject to the weaknesses of the conventional approximation procedure.

SUPPLY EFFECTS OF THE MODEL PARAMETERS

The elasticity of an explanatory variable is the percentage change in the dependent variable (in this case, NPS male HSG I-IIIA enlistments) with respect to a given percentage change in that explanatory, or independent, variable (population, unemployment, etc.). Elasticities of all variables in the model are summarized in Table 1.2. The data show, for example, that the population elasticity for Army white enlistments is .65. This means that a 10 percent change in this population category will result in a 6.5 percent change in white quality enlistments for the Army. While separate elasticities were computed for each Service by race for each of the variables, composite elasticities were also computed; these are shown on Table 1.3 on page 7.

Based on the individual and composite elasticities, the following observations appear relevant to this study.

- Population effect. The computed population elasticity for each Service is positive and significant; but, in each instance, the value is less than 1.0, meaning that a less-than-proportional decline in quality enlistments is expected to occur for a given percentage decline in the relevant youth population. The largest absolute and relative declines due to population are anticipated to occur in the Army while the smallest but still significant effect of the population decline impacts on the Air Force. Smaller population elasticities suggest a condition of excess supply of enlistable volunteers to a Service. This implies that the Air Force has the largest surplus and the Army the lowest (if any) and is thus the most sensitive to changes in population.

- Race-specific population effects. With the exception of the Air Force, population effects examined by race show that white enlistments are more sensitive to change in the white population than non-white enlistments are to changes in the non-white population. Since the real decline over the next decade in youth population is expected to occur in the white population, the differences in these elasticities tend to exacerbate the imbalance in the racial mix of enlistments when examined by Service.

Table 1.2

FINALIZED SUPPLY MODELS FOR I-IIIA, DHSG ACCESSIONS

Parameter		White		Non-white	
		Value	Standard error	Value	Standard error
	c	4.50		22.41	
	ϵ_q	.65	.10	.41	.15
	ϵ_r	.34	.09	.54	.20
Army	ϵ_u	.34	.11	-.42	.41
	ϵ_e	1.16	.24	4.11	.56
	R^2	.9624		.7505	
	c	3.54		7.02	
	ϵ_q	.44	.07	.35	.08
	ϵ_r	.56	.06	.63	.08
Navy	ϵ_u	-0-		-.53	.19
	ϵ_e	.61	.23	1.18	.32
	R^2	.9678		.9310	
	c	1.85		5.99	
	ϵ_q	.20	.09	.64	.08
	ϵ_r	.73	.09	.21	.08
USAF	ϵ_u	.25	.12	-0-	
	ϵ_e	-0-		1.17	.37
	R^2	.9495		.8755	
	c	-.76		5.31	
	ϵ_q	.57	.09	.55	.10
USMC	ϵ_r	.37	.08	.26	.10
	ϵ_u	-0-		-0-	
	ϵ_e	-0-		1.04	.45
	R^2	.9579		.8243	

Table 1.3

NON-RACE-SPECIFIC SUPPLY MODELS FOR I-IIIA DHSG ENLISTMENTS
(Values shown in the table represent elasticities)

Parameter	Army	Navy	Marine Corps	Air Force	DOD		
					White	Non-white	Total
Constant	7.11	3.81	.12	2.26	2.88	12.82	4.01
ε_q (population)	.62	.43	.57	.24	.46	.47	.46
ε_r (recruiters)	.37	.57	.35	.68	.51	.44	.50
ε_u (unemployment)	.23	-.04	-0-	.23	.17	-.28	.12
ε_e (pay)	1.59	.65	.15	.12	.55	2.36	.76

- Recruiter effect. The recruiter variable shows a positive and significant effect on quality enlistments for each Service. Relative magnitude of the recruiter effect when examined by Service shows a pattern opposite that of the population effects; that is, Air Force quality enlistments which are the least sensitive to population changes of the four Services are most sensitive to changes in the recruiter force. These differences are best exemplified by the marginal productivities of the respective Service recruiters which are computed from these elasticities.

Table 1.4

MARGINAL PRODUCTIVITIES OF SERVICE RECRUITERS
FOR NPS MALE, DHSG, I-IIIA ENLISTMENTS
(at CY 1975 supply levels)

Army	Navy	Marine Corps	Air Force
4.3	8.5	4.3	16.5

The results show that the Army and the Marine Corps have equivalent capability at the margin while the Navy and Air Force recruiters are two and four times as productive, respectively. These results are consistent with other evidence that enlistment preferences of youth differ markedly by Service. While youth generally express a preference for more than one

Service, the Air Force has a broader appeal to youth than the three remaining Services. This enlistment affinity for the Air Force is reflected in their production statistics.

- Unemployment effects. Interpretation of the results of the unemployment variables included in the model is not as clear and consistent as are the other parameters. Over all, the most significant unemployment effect is observed in the Army supply models. With regard to white Army enlistments, increasing unemployment has a positive effect, while for non-white Army enlistments it has a negative effect. The positive unemployment elasticity is what one would normally expect since depressed economic conditions make the military a more attractive option to a greater segment of the youth population. The anomolous effect of a rise in non-white enlistments as unemployment declines could be due to a number of reasons. One possible explanation is that non-whites traditionally are the last to be employed. Hiring practices by private employers under conditions of labor surplus typically result in a preference for white over non-white new hires. Thus, employment patterns in the civilian sector during certain phases of a business cycle can affect the racial composition of enlistees if the Services are recruiting in a nondiscriminatory mode. With respect to Navy enlistments, no unemployment effect for white enlistments was observed while a similar negative unemployment effect on non-white enlistments was observed. With respect to the Air Force, the opposite pattern occurred, that is, white enlistments appear to be affected by unemployment while non-white enlistments were unaffected. This latter observation may be attributed to the small size of the Air Force non-white enlistment population. No unemployment effects were observed on Marine Corps enlistments, either white or non-white.

- Compensation effects. The compensation variable is significant and relatively large for both Army and Navy enlistments. Further, when examined by race, the pay effect on Army non-white enlistments is approximately three and one-half times larger than for Army white enlistments. This observed difference is consistent with data that show significant differences in earnings potential for whites and non-whites. Thus, a comparable non-discriminatory salary offered by the military should be relatively more attractive to the non-white population. A similar although not as extreme effect is observed with respect to pay on Navy enlistments. Regarding the Air Force and the Marine Corps white enlistments, the pay variable had no effect. A noticeable effect of a magnitude similar to that of the Navy was observed for non-white enlistments. Again, civilian sector pay differences between whites and non-whites seem to be operative here.

ENLISTMENT FORECAST RESULTS

In order to generate enlistment forecasts over the next decade, it was necessary to develop forecasts of the four independent variables included in the model. Since in large part the objective of the study was to measure the impact that a change in population and unemployment would have on enlistments, the other two variables — number of recruiters and relative military/civilian compensation — were presumed to be held constant throughout the forecast period. Should this assumption be altered, different enlistment forecasts would necessarily occur. The assumption particularly with respect to compensation is not without its budget implications since a major share of the increase in manpower costs over the past several years has been driven by the need to maintain comparability with the civilian sector, and undoubtedly it will remain an expensive feature of the defense budget.

Some valid criticism attaches itself to the use of cross-sectional results in time series models. This technique is not without precedent, however. Economists, badgered by problems analogous to those afflicting this study, have traditionally resorted to just such an approach in demand studies. The technique is now standard; but after over 20 years of debate, basic questions of appropriateness have not been resolved.

Population Forecast Variable

The forecast of population trends employed in the enlistment supply models are data developed by the U.S. Census Population Series II. The trend in the 17-21-year-old male population is depicted graphically on Fig. 1.1 on the following page.

As a general overview, these census population trends for 17-21-year-old males show that:

- Total population for this group increases by 3 percent from 10.5 to 10.8 million over the period 1975-1978; however, in the period 1978-1990 the same group decreases by 17 percent, from 10.8 to 9.0 million.
- The white population increases by 2.4 percent, from 9.0 to 9.2 million over the period 1975-1978, and decreases 20 percent from 9.2 to 7.4 million over the period 1978-1990.

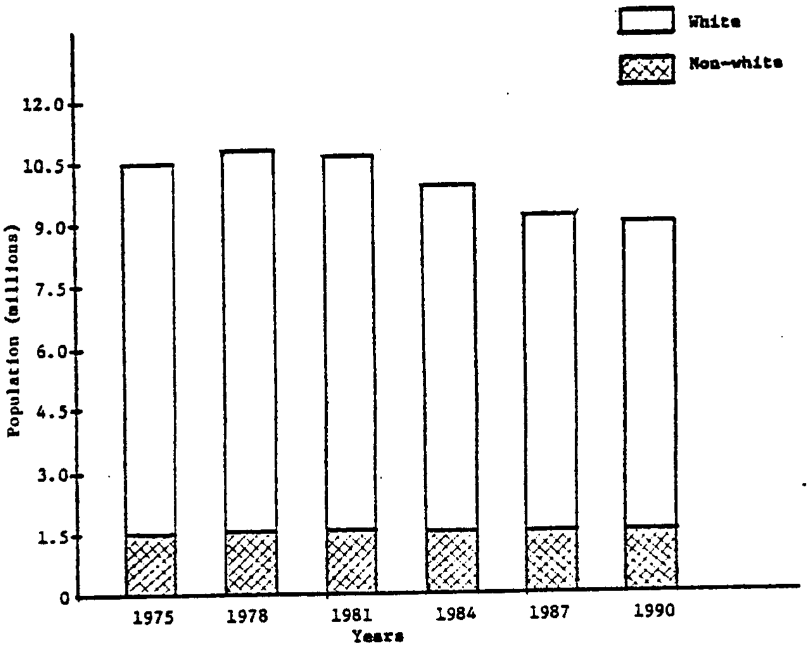

Fig. 1.1— POPULATION OF 17-21 YEAR OLD MALES
US CENSUS SERIES II
(In millions)

- In contrast to the white population, the non-white population increases 11 percent, from 1.5 to 1.7 million over the period 1975-1982, and levels off at 1.6 million by 1985.

Unemployment Forecast Variable

The forecasts of unemployment that are used as input for the supply model are those developed by the Congressional Budget Office and are the same ones used by CBO in forecasting enlistment supply in a recent budget issue paper.[1/] Table 1.5 displays the historical trend in general in male youth unemployment rates as well as the CBO projections.

[1/] The Costs of Defense Manpower: Issues for 1977, Congressional Budget Office, Congress of the United States, Washington, D.C., January 1977, especially Appendix A.

Essentially, CBO is forecasting the general unemployment rate will decline by some 45 percent over the decade 1975-1985.

Table 1.5

GENERAL AND 18-19 YEAR MALE UNEMPLOYMENT RATES: HISTORICAL TREND AND CBO PROJECTIONS

	Actual rates		CBO Projections (Jan '77 projection)		
Year	Total rate	18-19 year males	Year	Total rate	18-19 year males
1972	5.6%	14.0%	1978	7.3%	17.2%
1973	4.9%	11.4%	1979	7.0%	16.5%
1974	5.6%	13.3%	1980	6.3%	15.3%
1975	8.5%	19.0%	1981	5.7%	13.9%
1976	7.7%	17.6%	1982	5.1%	12.7%
Mar '77	7.3%	17.2%	1983-85	4.6%	11.4%
Jun '77	7.1%	N/A			

Quality Enlistment Forecasts

Using the Census Population Projections and the unemployment forecasts developed by CBO, the Service-and race-specific supply models developed in this study produced quality enlistment forecasts as shown on Table 1.6.

The data show that if none of the relevant variables change except population and unemployment, the Services are likely to recruit 22,000 fewer quality enlistments by 1986 than obtained in 1975. While the aggregate decline is approximately 16 percent for DOD, the Army experiences the largest decline, with the Air Force ranked second, followed by the Marine Corps and Navy. The population and unemployment effects on the Marine Corps and Navy quality enlistments are much less significant, primarily because of minimal or nonexistent unemployment effects.

Changes in the Racial Mix of Quality Enlistments

Included in Table 1.6 are estimates of the racial mix of the quality enlistment group. The Army, for example, has a sizable decline in quality enlistments coupled with a rise in the proportion of these enlistments that

Table 1.6

SUMMARY OF I-IIIA DHSG ENLISTMENT PROJECTIONS USING THE JANUARY '77 CBO UNEMPLOYMENT PROJECTIONS

	Army		Navy		Marine Corps		Air Force	
	Total	% Non-white	Total	% Non-white	Total	% Non-white	Total	% Non-white
1975 (actual)	55,995	14	52,249	8	22,194	14	44,216	10
1978	55,308	16	53,143	8	22,579	15	43,311	11
1982	50,893	19	52,843	10	22,226	15	41,007	11
1986	44,354	22	49,198	12	20,546	16	38,617	12
% 1975-86	-21%	--	-6%	--	-7%	--	-13%	--

are non-white. The significant increase in the proportion of quality non-white enlistments entering the Army by 1986 can be accounted for by the inverse unemployment effect described earlier, that is, a decline in unemployment tends to reduce white quality enlistments but increase non-white quality enlistments. Changes in non-white enlistment proportions in the other Services are not as dramatic, primarily because of the minimal or nonexistent impact unemployment has on quality enlistments to these Services.

ACCESSION BUDGET IMPLICATIONS OF THE ENLISTMENT SUPPLY FORECASTS

There have been a number of studies ongoing within DOD and elsewhere which are examining the feasibility and cost of satisfying its manpower requirements with alternative sources of supply. This includes greater use of women, civilians, contract hires, and prior service personnel. As a complement to these studies, it was decided to estimate what the cost is likely to be of continuing the present policy of recruiting male high-school graduates in numbers sufficient to maintain the current quality mix. Again, it was assumed that relative civilian/military compensation remains constant over the next decade and that the additional costs that accrue to the accession budgets are due solely to declines in both unemployment and population.

Optimal Accession Budget Allocations

In order to estimate the budgetary implications of the enlistment shortfalls, an optimal budget allocation model has been employed. This model was developed under previous contract work for Department of the Army and Office Secretary of Defense.[2/] Two fundamental assumptions were implicit in the modeling methodology. First is that the programs diminish in effectiveness at an exponential rate and at some point provide no additional enlistments for each increment in the budget. The second assumption is that various accession programs such as recruiters, advertising, and recruiter aids are to some extent substitutes for one another.

Accession Budget Production Functions at CY 1975 Enlistment Supply Levels

Based on output from the optimal budget allocation model, Fig. 1.2 displays the series of accession budget production functions for CY 1975 enlistment supply levels.

[2/] Documentation Report to Support the Analysis for Management of Recruiting Resources and Operations (AMRRO) System, General Research Corporation, CR-189, June 1977.

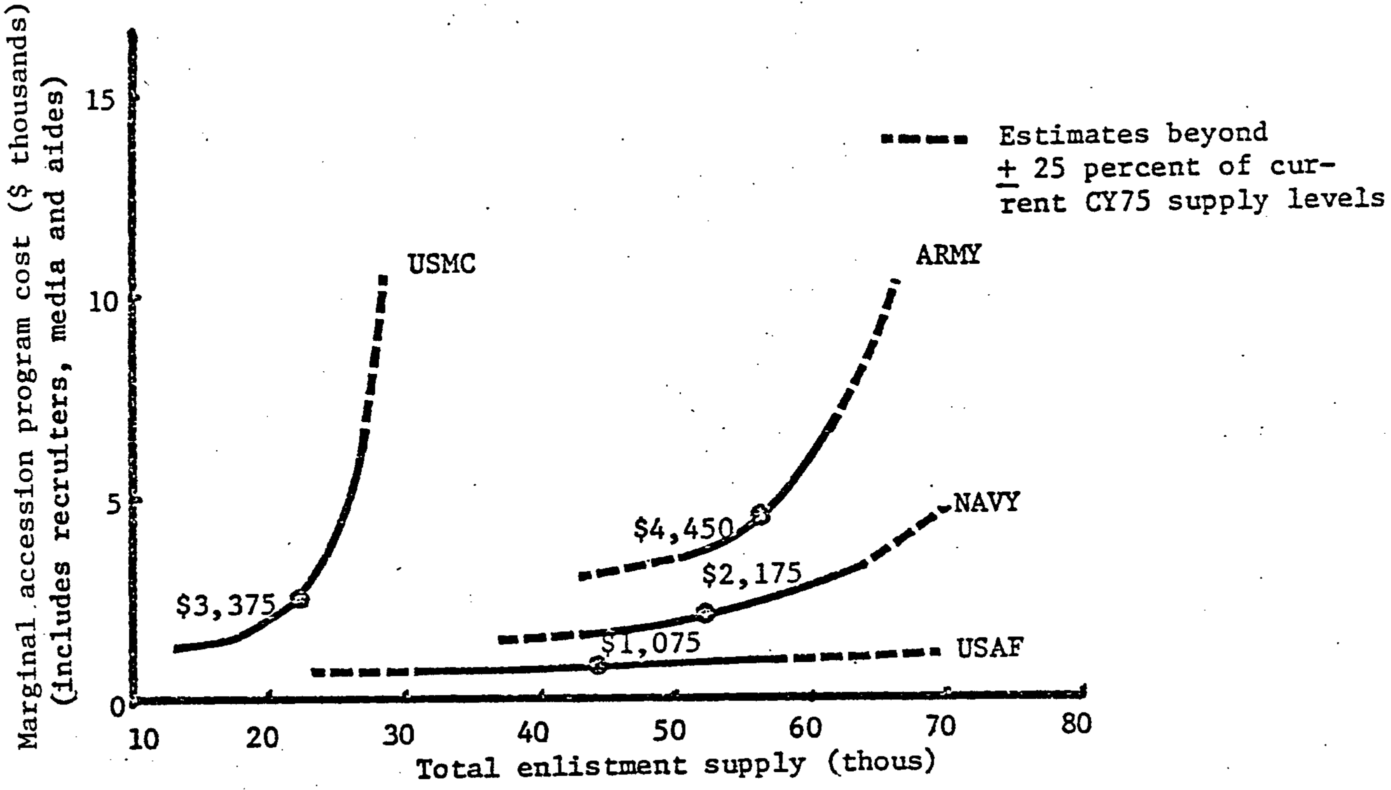

Fig. 1.2—Accession Production Functions NPS Male, DHSG, I-IIIA (at CY 75 supply levels)

The numbers annotated on each curve represent the marginal accession costs of recruiting the next additional quality enlistment at CY 1975 supply levels. What is most apparent in the curves is the difference in production capability between the Marine Corps and Air Force. It would appear that the Air Force can recruit essentially an unlimited supply of volunteers with only minimal increases in its marginal cost. The slope of the Air Force production function is consistent with the broad appeal the Air Force enjoys among the enlistable market. The Marine Corps is at the other extreme — it appeals to only a select segment of the market. The Marine Corps' recruiting strategy, which appears successful at current accession rates, presents a higher risk strategy when compared to the other

Services. Any increase in quality enlistment requirements for the Marine Corps will tend to drive up marginal recruiting costs much more sharply than the other Services.

Shifts in the Accession Budget Production Functions

Reduction in supply due to declines in unemployment and population tend to shift these Service accession production functions upward and to the left. This effect is depicted in Figure 1.3.

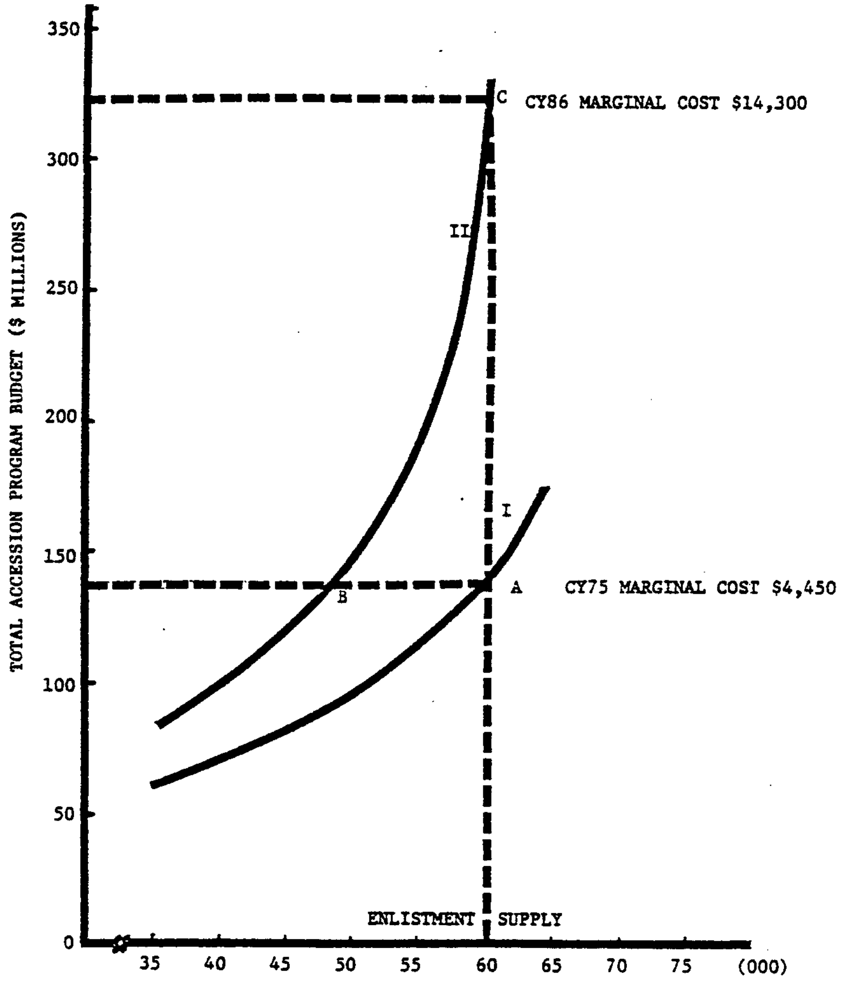

Fig. 1.3—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

This figure shows schematically the magnitude of shift in the Army production function that should occur when the supply of the enlistable market is reduced by declines in unemployment and population through projected CY 1986 levels. The curve labelled I is essentially an expanded version of the Army production function curve shown on Fig. 1.2. This is the production function the Army operated on when CY 1975 population and unemployment conditions were in effect. Point A represents the recruiting environment under CY 1975 resource levels. The slope of the curve at Point A ($4,450 per accession) is the marginal cost of recruiting the next additional quality enlistment in the CY 1975 recruiting environment.

The curve labelled II is the anticipated production function the Army will face at CY 1986 enlistment supply levels. Assuming no change in the accession budget beyond that established in CY 1975, Point B shows that the Army can anticipate recruiting 21 percent fewer enlistments should it decide (or be forced) to maintain a status quo in its accession budget. Should the Army wish to restore the total number of enlistments lost due to the population and unemployment decline, it will have to increase its accession budget along production function II up to Point C. At that point, it will have achieved the same number of enlistments it realized in CY 1975 but the marginal cost of the next additional enlistment is approximately three times larger than it was in CY 1975 conditions.

The curves shown in Fig. 1.3 indicate that without changes in the attractiveness of Army Service, a $90 million per year, i.e., a 56 percent, increase in the accession budget will be required by CY 1986.

Accession Budgets Required to Eliminate Quality Enlistment Shortfalls

The size of the accession budget for each Service required to overcome projected declines and their enlistments is shown on Table 1.7. As stated earlier for the Army, the table shows that a 21 percent shortfall in quality enlistments is projected by 1986 and a constant dollar increase in the accession budget of 56 percent will be required to increase the Army's market penetration sufficiently to offset this shortfall in enlistments.

The Navy's situation is much less severe than the Army and a shortage of enlistments is not projected until after 1982. This shortfall is

Table 1.7

CHANGE IN ACCESSION BUDGET TO OVERCOME PROJECTED DECLINE IN NPS MALE DHSG I-IIIA FROM CY 1975 LEVEL

	Shortfall from CY'75 level	Accession budget required to maintain CY'75 levels (millions CY'75 $)	Average cost per enlistment (CY'75 $)	Marginal cost per enlistment (CY'75 $)
		ARMY		
CY 1975 actual	55,995	$ 160.	$ 2,860	$ 4,450
CY 1978	(2,500)	175.	3,125	5,700
CY 1982	(6,500)	190.	3,400	6,900
CY 1986	(11,641)	250.	4,460	14,300
		NAVY		
CY 1975 actual	52,249	111.0	2,125	2,175
CY 1978	+ 894	107.5	2,060	2,100
CY 1982	+ 594	108.0	2,070	2,100
CY 1986	(3,051)	115.0	2,200	2,350
		MARINE CORPS		
CY 1975 actual	22,194	48.0	2,160	3,375
CY 1978	+ 385	46.5	2,100	3,050
CY 1982	+ 32	48.0	2,160	3,375
CY 1986	(1,648)	53.0	2,390	4,100
		AIR FORCE		
CY 1975 actual	44,216	54.0	1,220	1,075
CY 1978	(905)	55.0	1,240	1,100
CY 1982	(3,209)	56.5	1,280	1,150
CY 1986	(5,599)	58.0	1,310	1,175

expected to be less than 6 percent and a constant dollar increase to the accession budget of less than 4 percent would be sufficient to compensate for the Navy's shortage. In relative terms, the Marine Corps' projected shortfall is slightly larger than the Navy. A 10 percent increase in the accession budget will be required by 1986 to offset their projected shortage in quality enlistments. The relative shortfall projected for the Air Force is second only to the Army. A steady decline in quality enlistments is projected over the decade. This is projected to be 13 percent below the CY 1975 base levels. In spite of this relatively large decline for the Air Force, only a modest increase of 7 percent in the accession budget would be required to eliminate the shortfall. This relatively small increase in the Air Force accession budget reflects their highly productive recruiter force which at the margin is four times more productive than Army recruiters for the same quality group.

NEED FOR ADDITIONAL RESEARCH

This analysis has been a pioneering effort because no previous studies have been conducted that treat QMA population as an explanatory variable in the supply equation for volunteer enlistments. Previous studies have assumed that the supply of accessions varies proportionately with population and that this proportional relationship holds for all Services. The GRC analysis indicates that this popular assumption is not correct, that accession supply varies less-than-proportionately with population, and that this relationship differs among the Services.

Table 1.8 shows the implications of the GRC findings by comparing two projections of accession supply: one based on the GRC model, the other based on the assumption that supply varies proportionately with population. (Under both assumptions, the projections reflect the effect of projected changes in unemployment rates on the level of quality accessions. These effects differ among Services.) Table 1.8 shows that the projected decline in accessions between 1978 and 1986 will be only about half as great for the Navy, Marine Corps, and Air Force as would have been expected under the assumption of a proportional effect. The projected declines are most similar for the Army because the GRC analysis finds the population effect for the Army to be the closest to a proportional effect of all the Services.

Table 1.8

PROJECTED DECLINES IN QUALITY ACCESSION LEVELS UNDER ALTERNATIVE ASSUMPTIONS CONCERNING POPULATION EFFECTS [a]

(Percent change 1978 to 1986)

	GRC model	Proportionality assumed [b]
Army	- 20%	- 24%
Navy	- 7	- 14
Marine Corps	- 9	- 15
Air Force	- 11	- 24

---

[a] Assumes CBO unemployment projection of January 1977.

[b] Assumes effects of variables other than population are as estimated in the GRC model.

No claim is made here that this analysis conclusively establishes the effects of population. Ideally, a time-series model would have been developed to analyze the effect of population changes because policy makers interested in this effect naturally want to apply the results of any population analysis to future situations — by definition, a time-series application. GRC purposely selected a cross-sectional, rather than a time-series, model because time-series data provided too little variation in population over the AVF period to support valid statistical estimates. Although this decision was appropriate, it was not without its problems.

Some rather stringent assumptions have to be true before a cross-sectional model can be applied to time-series projections. These assumptions are least likely to be true if the model is incompletely specified — that is, if one or more variables are omitted from the model that are correlated with variables that are included in the model. This could result in attributing the effects of the omitted variables to the included variables, which would distort any projections based on the model's parameters. For this reason, additional research is required to determine whether different or additional variables should be included in the model and to test whether the model's results are stable when the model is applied to additional data. Possible modifications to the model include the use of youth unemployment rates and race-specific unemployment data rather than general unemployment rates. In addition, earnings statistics more closely tied to the youth labor market could be substituted for the manufacturing earnings data used in the present analysis.

This additional research was not possible in the present study because of study resource limitations. GRC believes strongly that this study ought not to be ignored but, rather, that it be supported with additional analysis.

Also because of resource limitations, the present analysis does not address the implications of the study findings for the optimal allocation of recruiters across geographical areas. In general, the Services tend to allocate their recruiters in proportion to population; the findings of the GRC model indicate that the best relationship between recruiter level and population is not a simple proportional one and that, in addition, the best relationship depends on unemployment rates and relative civilian wages across geographical areas. With modest additional analysis, it would be possible to calculate how much quality accession levels could be increased by reallocating recruiters.

Chapter 2

BACKGROUND AND PURPOSE

OBJECTIVES OF THE STUDY

This report was prepared for the Office Assistant Secretary of Defense, Manpower, Reserve Affairs and Logistics. The study was prompted by concern that the AVF faces serious manpower supply problems over the next decade. Specifically, four issues were addressed in the study:

- What effect, if any, will a projected decline in the youth population (17-21-year-old) have on quality enlistments over the next decade?
- What will be the effect on the supply of quality enlistments if the economy continues to improve and the unemployment rate continues to decline?
- If a decline in quality enlistments is projected over the next decade, what additional recruiting resources would be required to offset this decline?
- What are the manpower policy implications of attempting to sustain the AVF in the face of potential shortages of quality volunteers?

BACKGROUND INFORMATION SUPPORTING THE RATIONALE FOR THE STUDY

High-School Graduates: The Quality Recruiting Market

In examining public testimony, it is quite clear that DOD has measured the success of its AVF accession program by the number of male high-school graduates they are able to recruit. There are essentially two reasons for this. The first is that high-school graduates in contrast to non-graduates represent a better employment risk and the services typically experience considerably less attrition with a high-school graduate, as is evident from the following table.

Table 2.1

TRENDS IN MALE ENLISTED ATTRITION RATES DURING THE FIRST
TWO YEARS OF SERVICE
(All services combined)

Cohort	Percent attrition by year of accession			
	FY 1971	FY 1972	FY 1973	FY 1974
Total males	20.7	21.3	23.6	29.1
Male HSG	14.3	15.5	17.1	17.9
Male non-HSG[a]	32.2	32.4	35.2	41.7

[a] Includes GEDs

Source: Defense Manpower Data Center

While the overall trend shows that attrition has been rising, male high-school graduates experience an attrition rate of less than one-half that of their non-graduate counterparts. Given the failure rate of non-graduates and the attendant costs associated with them, it is understandable why the services concentrate their energy and resources on recruiting high-school graduates.

The second reason for recruiting high-school graduates is basically that they are an identifiable market with uncertain career aspirations that can be both contacted and influenced by military recruiters. In certain respects, high-school seniors can be considered a homogeneous market who are segmented by the educational system. Once high-school seniors graduate, they become less easily identified and have, for the most part, already made career commitments that would exclude them as good prospects by military recruiters.

One should not conclude from this, however, that the male high-school senior segment of the youth population is the only market recruiters actively pursue, but it is unquestionably their prime target at present. In view of the fact that this market will tighten considerably, the services will have to both sharpen their recruiting techniques as well as broaden the enlistable market by more active recruiting of alternative sources of supply, particularly females and possibly college students. At the present time, slightly more than half of the graduating class of male high-school seniors continue their education in institutions of higher learning. It is worth noting, however, that approximately 40 percent of this group leave these institutions by the end of 3 years. Surprisingly, quite a few of these individuals enlist in the military as evidenced by the fact that approximately 15 percent of NPS enlistments, responding to a May 1975 AFEES survey, claimed some post-high-school educational experience prior to enlisting.

Trends in High-School Graduate Enlistments

For the 12-month period ending June 1977, the services enlisted a combined total of approximately 260,000 diploma high-school graduates or 67 percent of their NPS male and female accessions. This is roughly 5 percent fewer than the number recruited in the previous 12-month period, and the majority of this decline occurred in the Army. The trend in the proportion of NPS enlistments who are high-school graduates appears in the following table.

Table 2.2

TRENDS IN DIPLOMA HIGH-SCHOOL GRADUATE ACCESSIONS
EXPRESSED AS A PERCENT OF NPS ENLISTMENTS

Fiscal year	Army	Navy	Marine Corps	Air Force	DoD
FY 1964 [a]	67	58	61	84	68
FY 1971	62	75	48	85	69
FY 1973	60	71	51	87	67
FY 1974	50	52	50	92	61
FY 1975	58	71	53	91	65
FY 1976	59	76	62	89	69
Jul76-Jun77	54	73	67	87	67
FY 1977 [b]	52	71	65	87	65

[a] Some GEDs included.

[b] Through June.

Statistics presented in this form result in no clear pattern of the quality mix in military enlistments. There are probably as many administrative controls as there are market forces that are affecting high-school graduate accession rates for each service. The Army at present is several percentage points behind its objective of 68 percent diploma graduates and it appears very unlikely that such a target is attainable at present accession requirement levels. Overall, the Marine Corps shows the best improvement in its high-school graduate mix, but is still below its target of 70 percent diploma graduates of NPS enlistments. While it is difficult to say categorically that DOD is experiencing a downward trend in its high-school graduate enlistment level, it is clear that at best they have reached a plateau. The major reason for hesitancy in claiming a clear downward trend in high-school enlistments is the fact that the stock of high-school graduates in the Delayed Enlistment Pool is approximately 60 percent higher than the like period last year. This growth in the DEP can be partially ascribed to the cancellation of the GI Bill program at the end of 1976 and the corresponding surge in DEP enlistment contracts signed prior to the end of that year.

Trends in Unemployment

One of those market forces that appears to affect the level of quality enlistments is the civilian unemployment rate. Trends and projections of these unemployment rates are shown in the following table.

Table 2.3

GENERAL AND 18-19 YEAR MALE UNEMPLOYMENT RATES: HISTORICAL TREND AND CBO PROJECTIONS

	Actual rates		CBO Projections (Jan '77 projection)		
Year	Total rate	18-19 year males	Year	Total rate	18-19 year males
1972	5.6%	14.0%	1978	7.3%	17.2%
1973	4.9%	11.4%	1979	7.0%	16.5%
1974	5.6%	13.3%	1980	6.3%	15.3%
1975	8.5%	19.0%	1981	5.7%	13.9%
1976	7.7%	17.6%	1982	5.1%	12.7%
Mar '77	7.3%	17.2%	1983-85	4.6%	11.4%
Jun '77	7.1%	N/A			

CY 1975 represents a peak year of unemployment and the trough of the most recent economic recession. This is also the year analyzed by GRC to estimate the effect that unemployment, compensation, population and recruiters have on quality enlistments across the 50 states and the District of Columbia.

The unemployment projections shown on Table 2.3 are the same ones used by CBO in forecasting enlistment supply in a recent issue paper.[1] These same unemployment projections developed by CBO are used in this report to develop enlistment forecasts. Note that a comparison of the actual rates with the CBO projections shows that the current (June 1977) general unemployment rate is already below the average projected by CBO for 1978. If this trend continues, the effect that declining unemployment has on enlistments will be more immediate. This fact should be kept in mind in evaluating the validity of the estimates developed in this report.

Trends in Youth Population

Coupled with the projected decline in unemployment is a known decrease in youth population over the next decade and beyond. This decline in population is depicted on Fig. 2.1. Detailed data on the number and rate of decline are displayed on Tables 2.4 and 2.5.

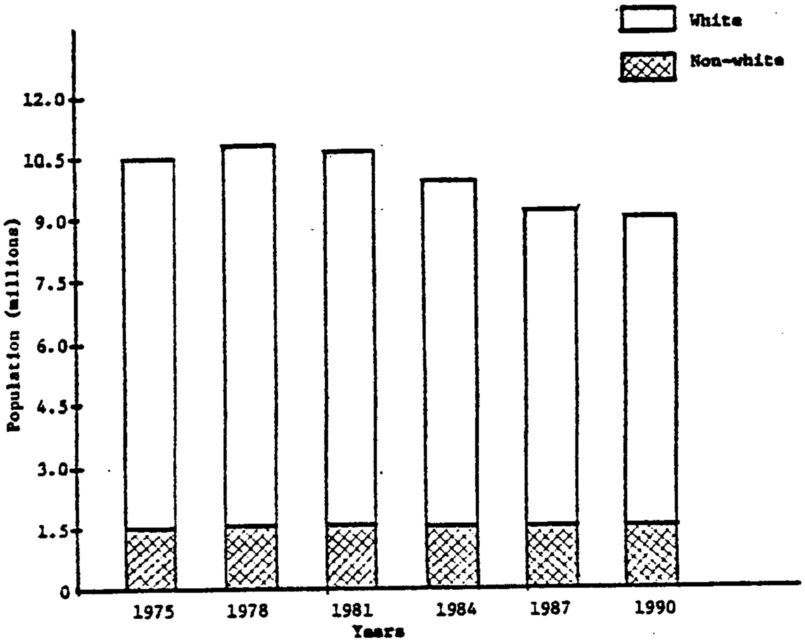

Fig. 2.1— POPULATION OF 17-21 YEAR OLD MALES
US CENSUS SERIES II
(In millions)

---

[1] Budget Issue paper, "The Costs of Defense Manpower: Issues for 1977," especially App A, Congressional Budget Office, Congress of the United States, Washington, D.C., January 1977.

Table 2.4

PERCENT CHANGE IN MALE POPULATION, 17-21 YEARS OLD, BY RACE (SERIES II)

As of 1 July	Total		White		Non-white		Black		Other	
	Percent change		Percent change		Percent change		Percent change		Percent change	
	Year to year	Cumulative from 1975	Year to year	Cumulative from 1975	Year to year	Cumulative from 1975	Year to year	Cumulative from 1975	Year to year	Cumulative from 1975
1976	+ 1.3	+ 1.3	+ 1.0	+ 1.0	+ 3.0	+ 3.0	+ 2.6	+ 2.6	+ 5.9	+ 5.9
1977	+ 0.8	+ 2.1	+ 0.6	+ 1.6	+ 2.2	+ 5.2	+ 1.8	+ 4.4	+ 5.0	+10.9
1978	+ 0.9	+ 3.1	+ 0.8	+ 2.4	+ 1.9	+ 7.1	+ 1.7	+ 6.1	+ 3.7	+14.6
1979	- 0.2	+ 2.9	- 0.4	+ 2.0	+ 1.1	+ 8.2	+ 0.9	+ 7.0	+ 2.6	+17.2
1980	- 0.5	+ 2.5	- 0.7	+ 1.3	+ 1.1	+ 9.3	+ 0.7	+ 7.7	+ 4.0	+21.2
1981	- 0.7	+ 1.8	- 0.9	+ 0.4	+ 0.7	+10.0	+ 0.3	+ 8.0	+ 2.9	+24.1
1982	- 1.5	+ 0.3	- 1.8	- 1.4	+ 0.3	+10.3	- 0.1	+ 7.9	+ 2.8	+26.9
1983	- 2.8	- 2.5	- 8.1	- 9.5	- 0.6	+ 9.7	- 1.3	+ 6.6	+ 4.1	+31.0
1984	- 3.0	- 5.5	- 3.3	-12.8	- 1.6	+ 8.1	- 1.9	+ 4.7	+ 0.4	+31.4
1985	- 3.2	- 8.5	- 3.5	-16.3	- 1.7	+ 6.4	- 2.2	+ 2.5	+ 1.7	+33.1
1986	- 2.8	-11.0	- 3.1	-19.4	- 1.2	+ 5.2	- 1.8	+ 0.7	+ 2.1	+35.2
1987	- 1.4	-12.2	- 1.6	-21.0	- 0.4	+ 4.8	- 1.0	- 0.3	+ 3.3	+38.5
1988	+ 0.2	-12.1	- 0.0[a]	-21.0	+ 1.3	+ 6.1	+ 0.9	+ 0.6	+ 3.6	+42.1
1989	- 0.8	-12.8	- 1.1	-22.1	+ 0.9	+ 7.0	+ 0.4	+ 1.0	+ 3.5	+45.6
1990	- 1.5	-14.1	- 1.9	-24.0	+ 0.2	+ 7.2	- 0.3	+ 0.7	+ 2.6	+48.2
1991	- 2.2	-16.0	- 2.5	-26.5	- 0.6	+ 6.6	- 1.0	- 0.3	+ 1.5	+49.7
1992	- 2.3	-17.9	- 2.9	-29.4	- 0.3	+ 6.3	- 0.6	- 0.9	+ 4.7	+54.4
1993	- 2.2	-19.7	- 2.6	-32.0	- 0.4	+ 5.9	- 1.2	- 2.1	+ 3.4	+57.8
1994	+ 0.3	-19.4	+ 0.1	-31.9	+ 1.4	+ 7.3	+ 0.5	- 1.6	+ 5.7	+63.5
1995	+ 2.5	-17.4	+ 2.4	-29.5	+ 2.8	+10.1	+ 2.1	+ 0.5	+ 5.7	+69.2
1996	+ 3.6	-14.4	+ 3.7	-25.8	+ 3.6	+13.7	+ 2.5	+ 3.0	+ 8.1	+77.3
1997	+ 3.9	-11.1	+ 4.2	-21.6	+ 2.5	+16.2	+ 2.1	+ 5.1	+ 4.1	+81.4
1998	+ 3.8	- 7.8	+ 4.1	-17.5	+ 2.3	+18.5	+ 1.9	+ 7.0	+ 3.7	+85.1
1999	+ 3.3	- 4.7	+ 3.6	-13.9	+ 1.9	+20.4	+ 1.5	+ 8.5	+ 3.3	+88.4
2000	+ 2.7	- 2.2	+ 2.9	-11.0	+ 1.5	+21.9	+ 1.1	+ 9.6	+ 3.0	+91.4

[a] Less than 0.05%

Table 2.5

MALE POPULATION, 17-21 YEARS OLD, BY RACE (SERIES II)[a], 1975-2000
(thous)

As of 1 July	Total	White	Non-white	Black	Other	Percent white of total	Percent non-white of total	Percent black of total	Percent Other of total
1975	10481	8980	1501	1331	170	85.7	14.3	12.7	1.6
1976	10618	9072	1546	1366	180	85.4	14.6	12.9	1.7
1977	10707	9128	1580	1391	189	85.2	14.8	13.0	1.8
1978	10808	9199	1610	1414	196	85.1	14.9	13.1	1.8
1979	10791	9162	1628	1427	201	84.9	15.1	13.2	1.9
1980	10740	9094	1646	1437	209	84.7	15.3	13.4	1.9
1981	10669	9012	1657	1442	215	84.5	15.5	13.5	2.0
1982	10511	8850	1662	1441	221	84.2	15.8	13.7	2.1
1983	10215	8565	1652	1422	230	83.8	16.2	13.9	2.3
1984	9909	8282	1626	1395	231	83.6	16.4	14.1	2.3
1985	9593	7993	1599	1364	235	83.3	16.7	14.2	2.5
1986	9328	7749	1580	1340	240	83.1	16.9	14.4	2.5
1987	9199	7624	1574	1326	248	82.9	17.1	14.4	2.7
1988	9217	7621	1595	1338	257	82.7	17.3	14.5	2.8
1989	9145	7534	1609	1343	266	82.4	17.6	14.7	2.9
1990	9005	7392	1612	1339	273	82.1	17.9	14.9	3.0
1991	8808	7207	1602	1325	277	81.8	18.2	15.0	3.1
1992	8605	7000	1607	1317	290	81.3	18.7	15.3	3.4
1993	8417	6816	1601	1301	300	81.0	19.0	15.5	3.5
1994	8444	6821	1624	1307	317	80.8	19.2	15.5	3.7
1995	8656	6984	1670	1335	335	80.7	19.3	15.4	3.9
1996	8971	7240	1730	1368	362	80.7	19.3	15.2	4.1
1997	9317	7544	1774	1397	377	81.0	19.0	15.0	4.0
1998	9669	7855	1814	1423	391	81.2	18.8	14.7	4.1
1999	9985	8136	1848	1444	404	81.5	18.5	14.5	4.0
2000	10253	8376	1876	1460	416	81.7	18.3	14.2	4.1

---

[a] US Census, Current Population Reports, Series P-25, No. 601, issued October 1975.

As a general overview, the census population trends for 17-21-year old males show that:

- Total population for this group increases by 3 percent, from 10.5 to 10.8 million over the period 1975-78; however, from the period 1978-90, this same group decreases by 17 percent, from 10.8 to 9.0 million.
- The white population increases by 2.4 percent, from 9.0 to 9.2 million over the period 1975-78, and decreases 20 percent, from 9.2 to 7.4 million over the period 1978-90.
- In contrast to the white population, the non-white population increases 11 percent, from 1.5 to 1.7 million over the period 1975-82 and levels off at 1.6 million by 1985.

As is evident from these data, the real decline occurs in the white population and, because of this, there are changes in both the total population and racial composition that have important implications for sustaining a quality AVF that is also representative of the characteristics of the U.S. population. In developing enlistment forecasts for this report, the rates of change in both white and non-white populations under the census Series II projections were used.

While the actual enlistment forecasts for this report are based on census population trends, it is worth noting that the rate of decline by geographic area is not uniform. GRC is currently in the process of turning over to the Defense Manpower Data Center its Qualified Military Available (QMA) population projection system. An examination of the QMA projections by state reveals considerable variance in the rate of projected decline as shown in the sample of ten states in Table 2.6 on the following page.

These data show that the prime market of military recruiters is projected to decline by 14 percent for both the top ten states (ranked by population) and the nation as a whole. When the trends in the individual states are examined, however, significant differences are apparent such as New York, which is projected to experience only a 1 percent decline in this population group, while at the other extreme, Michigan's prime enlistment market is expected to shrink by 22 percent over the next decade. The primary reason for this variation in rates of decline is the difference in net migration that is experienced by each of the states. The population

Table 2.6

DISTRIBUTION OF THE TOP TEN STATES
QMA I-IIIA MALE HSG
17-21 YEAR OLD

	CY 1975	CY 1985	% Δ 1975-85
CALIFORNIA	158,201	137,543	- 13%
NEW YORK	129,246	127,982	- 1%
PENNSYLVANIA	109,622	89,323	- 19%
ILLINOIS	110,462	95,194	- 14%
OHIO	107,692	89,090	- 18%
MICHIGAN	85,624	67,529	- 22%
TEXAS	63,751	53,301	- 17%
INDIANA	55,626	48,869	- 13%
WISCONSIN	55,395	47,328	- 15%
MINNESOTA	54,195	48,281	- 11%
TEN STATE TOTAL	929,814	804,440	- 14%
NATIONAL TOTAL	1,652,071	1,417,359	- 14%
TEN STATE % OF TOTAL	56.3%	56.8%	

projections displayed on Table 2.6 assume that the current pattern of net migration will remain unchanged through the 1980's. These differences in rates of decline by geographic region are important because they will affect the placement of recruiters, and it points to the need for DOD to track population movements on a regional basis. The migration data used in the QMA system are available from the states on an annual basis, and CY 1974-75 data were used in forecasting QMA. In turning the GRC-developed QMA system over to the Defense Manpower Data Center, DOD will have in-house capability to track migration trends on an annual basis.

Trends in School Enrollment

In monitoring the overall population dynamics in the marketplace, DOD needs to be aware of the patterns in high-school completion rates and post-high-school continuation rates. For example, high-school completion rates for both males and females have remained practically unchanged over the past decade, as shown in the following table.

Table 2.7

NUMBER OF HIGH SCHOOL GRADUATES COMPARED WITH POPULATION 17-YEAR-OLDS

School year ending	Male		Female	
	Graduates (000)	Percent of 17-year-olds	Graduates (000)	Percent of 17-year-olds
1940	579	46%	643	52%
1950	571	54%	629	61%
1965	1,314	74%	1,351	79%
1975	1,541	72%	1,599	77%

Source: The Condition of Education, 1977 Edition, National Center for Education Statistics, p 174.

As the data show, approximately 75 percent of the 17-year-old population completed high school in 1975. While there continues to be some growth in completion rates, especially for black females, DOD cannot expect the population of the high-school graduate market to be measurably affected by any change in high-school completion rates over the next several years. Given that the high-school graduate completion rate is likely to remain constant, population trends will be the driving force behind the size of this high-school graduate market. As we have noted elsewhere in this chapter, the population of this prime age group is expected to decline substantially over the next decade.

The other factor to consider is college enrollment patterns. Since the decision to enter either 2- or 4-year institutions of higher learning effectively excludes that individual from the enlistable market for the active force, unlike high-school completion rates, the pattern in college enrollments is not clearly defined. This is exemplified by the data on Table 2.8 on the following page. For the 1976-77 academic year, the data show a slight decline in the total population of those enrolled in a 4-year college. Perhaps of more interest, however, is the pattern of freshman enrollment changes over the past several years. It is difficult

Table 2.8

ANNUAL PERCENTAGE CHANGE IN COLLEGE ENROLLMENTS, MALE AND FEMALE
(For 4-year and related institutions)

Year	Full-time	Part-time	Grand total	Freshmen
1970	+ 4.9	+ 2.2	+ 4.2	+ 3.8
1971	3.2	.9	2.6	- .7
1972	- .4	2.1	.2	- 3.1
1973	2.1	5.9	1.8	- 1.7
1974	2.0	8.0	3.7	4.6
1975	2.9	7.7	4.3	7.4
1976	.2	- 3.2	- .8	3.7

Source: Collegiate Enrollments in the U.S., 1976-77, American College Testing Program, 1977.

to detect any clear trend in the data and an extrapolation of these results to develop projections is fraught with uncertainty. For example, the growth rate for male college freshmen in the present academic year compared with last year is 2.6 percent contrasted with 4.9 percent for women. Thus, the impact that females (and minorities) have on the freshman enrollment population is a key factor in estimating the size of the male enlistable market. [2]

Enrollment patterns in 2-year colleges are also difficult to interpret. One study estimates that freshman enrollment in 2-year colleges increased by 8.4 percent in the 1976-77 academic year when compared to the previous year. However, when examined by sex, the increase was only 2 percent for males vs 17 percent for females. [3]

---

[2] Collegiate Enrollments in the U.S., 1976-77, American College Testing Program, 1977, p 12.

[3] College Enrollments in American 2-Year Institutions, 1976-77, American College Testing Program, 1977, p 14.

The effect that a declining youth population will have on college enrollments is very uncertain. The trend toward excess capacity in the education industry as the population declines may increase competition for the prime candidate of military recruiters—the high-school graduate. The extent of educational subsidies by Federal, state and local governments can be a contributing factor to this excess capacity and actually induce unnecessary and counterproductive competition for the reduced youth market. To some extent, the loss of the GI bill will aggravate the excess capacity condition and likely prompt educational administrators to more aggresively recruit non-veteran, high-school graduates to offset this loss.

While military recruiters actively pursue the recent high-school graduate, it is misleading to think that the vast majority of NPS DHSG enlistments are recent high-school graduates. The AFEES survey conducted in May of 1975 provides an estimate of the age distribution of those immediately entering active duty or enlisting in the DEP. This is shown on the following table.

Table 2.9

PERCENTAGE DISTRIBUTION BY AGE FOR MALE
AND FEMALE DHSG ENLISTEES ACCORDING TO
THE MAY, 1975 AFEES SURVEY

Age	17	18	19	20	21	>21	Total
NPS	7	21	24	16	11	20	100%
PS + NPS	6	19	22	15	10	28	100%

Somewhat surprisingly, the results show that one-fifth of NPS DHSG enlistments passed their 21st birthday. The data suggest that for a large number of high-school graduates there is a considerable lapse of time between completion of high school and actual enlistment in the military. While the AFEES survey data represent only a one-month's snapshot which is subject to seasonal bias, the results are probably reasonably indicative of the true age distribution of enlisting high-school graduates.

Additional information on the AFEES survey shows that about 15 percent of these high-school graduates also claim some form of post-secondary educational experience. Thus, it would appear that a significant share of the enlistable market would appear to be college-leavers, using the military as an alternative life-style. Like military service, the attrition rate of post-secondary educational institutions is quite high. Data collected on the enrollment status of the high-school class of 1972 and 2 follow-up years are displayed in the following table.

Table 2.10

ENROLLMENT STATUS IN POST-SECONDARY EDUCATION OF THE HIGH-SCHOOL CLASS OF 1972
(Percent enrolled in post-secondary education)

October 1972			October 1973			October 1974		
White	Black	Hispanic	White	Black	Hispanic	White	Black	Hispanic
56	50	47	47	40	39	39	34	31

Source: U.S. Department of Health, Education, and Welfare, National Center for Education Statistics, National Longitudinal Study of the High School Class of 1972.

According to this survey, approximately 55 percent of the 1972 high-school class continued their education. Two years later the members of this class who were enrolled in school declined to less than 40 percent. Thus, almost a third of those entering post-secondary education failed to complete a full 2 years of enrollment. While some of this decline could be attributed to graduation from 2-year colleges, vocational and technical schools, a good deal of the decline can also be attributed to failure to complete original enrollment plans. The data from the National Longitudinal Study offers corroborative evidence that a sizeable college dropout market exists and that it appears that the Services are already recruiting a significant number from this enlistable segment of the market. Generally speaking, the evidence displayed here shows that the enlistable market of male high-school graduates is somewhat broader than what conventional thinking would lead one to believe.

Chapter 3

METHODOLOGICAL CONSIDERATIONS IN DEVELOPING AN ENLISTMENT SUPPLY MODEL

GENERAL

This chapter discusses the econometric modeling effort aimed at deriving supply models for non-prior service, I-IIIA, diploma high school graduate male enlistees. This is by no means the first work dealing with enlistment supply models, and perhaps a word about the motivation for undertaking yet another supply study is in order.

Two primary considerations made further work appear unavoidable, namely,

- Since sustaining the all volunteer force requires that <u>each</u> individual Service be capable of recruiting a sufficient number of quality personnel to meet its needs, it is necessary to have comparable supply models for each of the four Services, and
- Since the impending population decline is perhaps the largest single obstacle to maintaining the AVF, a Service-by-Service indicator of population impact is called for. Such indicators are not available from previous work.

Additionally, the availability of more reliable population data together with a contemplated methodological improvement (discussed below) offered a reasonable chance of successfully addressing the question of population effects.

THE SUPPLY MODEL

Guidelines for Model Selection

The hypothesis underlying the specification of a supply model is that unintuitive results which have arisen in past studies of enlistment supply arose in large part from data ambiguities and inaccuracies. Accordingly, in specifying the model the following guidelines were observed.

- The unit of analysis and the time period to be considered should be chosen so as to minimize the degree of estimation which must be applied to the source data in order to satisfy the requirements of the model.
- In the absence of an obviously theoretically superior alternative, the functional form of the model should be chosen so as to minimize the distortion induced by uncorrectable defects in the source data.

The Analysis Technique

The supply of quality accessions can be modelled either cross-sectionally for a given time period, or as a time series, or as a combination of the two. Inasmuch as the ultimate objective of this analysis is to predict annual quality accession levels, an annual time-series model is the natural choice. Unfortunately, two distinct considerations diminish the attractiveness of this alternative.

- Paucity of Relevant Data. As the end of the draft was declared in January 1973, only 5 years of AVF data are available for analysis. Consequently, an annual time-series analysis of purely AVF data is not feasible. Due to the vastly different environments offered by the Services during the draft and all-volunteer eras, extension of the annual time-series to include draft era data is an apples-and-oranges proposition warranting considerably less than unqualified acceptance. Disaggregation of the annual series into quarterly or monthly time-series might be expected to produce a reasonable model. It is not clear, however, that a quarterly or monthly model would be appropriate for long-term annual predictions. Because of the relatively small variation in population since the inception of the AVF, no information regarding the impact of population changes can be expected.
- Necessity of Unintuitive and Arbitrary Assumptions. Since population is expected to decrease significantly in the projection period, its effect cannot be ignored. This is true even though, because of little population variability, a population effect cannot be detected by time-series analysis of relevant historical data. The logical result of all this is that some assumption(s) regarding population effects must be made apart from the time-series model.

On the surface, perhaps the most appealing assumption is that for each Service, the decline in quality accessions is proportional to the decline in quality population. There are no empirical data to support this assumption and there are, in fact, objections to it. Two suggest themselves immediately:

- Quality accessions can be divided into two groups: persons who are contacted by a recruiter and subsequently persuaded to enlist, and persons who contact the recruiter (perhaps after an advertising contact) with some interest in enlisting. Of these two groups, the latter can more probably be thought to vary proportionately with the population (when all other relevant factors remain constant). The situation of the former group is more complex. When the population pool susceptible to enlistment in a Service when actively recruited is larger than can be contacted effectively by the available recruiters, marginal declines in the susceptible population should have little or no effect upon accessions. Only when all the available population is being contacted can accessions be expected to decline proportionately with population.
- Apart from the foregoing considerations, it seems unlikely that the impact of a population decline will be the same on all Services. The pools of persons susceptible to enlistment in the respective Services are probably not of equal size. Certainly, the requirements of the individual Services for quality personnel are not the same. If one Service requires relatively few of the quality personnel in its pool while another Service requires virtually all the quality personnel in its pool, it seems unlikely that the impact of a population decline will be the same for both.

On the basis of the foregoing, it is difficult to see how a pure time-series analysis can account for population effects without arbitrary external assumptions. As the most obvious and plausible assumption regarding population effects seems less than adequate for modelling population impact on the individual Services, some other approach seems desirable.

At this point, there appears to be no alternative to modelling population effects cross-sectionally. A cross-sectional model is possible since population does vary considerably across region and can be seen to have an effect on the number of quality accessions. The obvious question arises as to the appropriateness of using cross-sectional results for the prediction of phenomena through time. There appears to be no definitive resolution of this question in the literature.

Precedents for applying cross-sectional results to time series exist in economics where such application is conventional for demand studies. [1/] After over 20 years of debate, however, questions concerning the appropriateness of this technique are still unresolved. That the analysis technique has persisted for so long in the face of criticism indicates that no obviously better alternative has been found.

Other important variables, specifically recruiting effort and unemployment, lend themselves to cross-sectional modelling. For the investigation in hand, a cross-sectional unemployment result is probably superior to a time series result. Such superiority derives from the concensus that cross-sectional unemployment effects are more indicative of the long-term impact of unemployment than effects measured over a relatively short time series.

An important variable which cannot be captured in a cross-sectional analysis is the ratio of military to civilian pay. Consequently, the assumption must be made that the pay ratio remains essentially constant through time. This assumption is probably not too unrealistic.

A pooling of cross-sectional and time series data offers an attractive possibility for overcoming some of the analytical difficulties cited above. This approach ought to be tried. Unfortunately, during this study, only one relevant cross-sectional observation of recruiter distributions was available so no fluctuations through time could be investigated.

The foregoing considerations argue for a cross-sectional modelling effort as the least objectionable feasible approach. Because data for each of the factors of interest can be obtained at the state level without resort to further approximation, the unit of analysis in this study is taken to be the state.

The Time Frame of the Analysis

Since measures of the factors of interest are directly obtainable on an annual basis, the choice of time frame was accordingly limited to the choice of an appropriate calendar or fiscal year. Ultimately, calendar year 1975 was selected as the latest time period for which relevant data were finalized at the state level.

[1/] J. Johnston, Econometric Methods, McGraw-Hill, New York, 1972, p 164.

The decision to perform the cross-sectional analysis by state for CY75 arose from, and is in accordance with, the first of the guidelines adopted for model selection.

Definition of Variables

The variables selected for the analysis are defined in this section. The various known uncorrectable defects present in the data for each of the variables are included in the presentation, but a discussion of the steps taken to remedy these flaws is deferred until the following section. Source data for the variables are given in Appendix B. Correlation matrices, means, and standard deviations for the variables are presented in Appendix C.

N: Quality Accessions: The dependent variable sought for the analysis is the number of quality accessions accruing to the respective Services in CY75. A fundamental assumption of the analysis is that this group is supply-limited, i.e., that the number of quality accessions is limited by the supply of such persons who can be induced to join the military rather than by the military's demand. In the analysis, this group is defined to be non-prior service, diploma high school graduate, 17-21-year-old males classified in mental categories I-IIIA.

The accession data for all Services were obtained from magnetic tape files provided by the United States Army Recruiting Command (USAREC). Accession data for the Army, Navy and USAF, although at odds with monthly reports published by USAREC (i.e., Supplemental Enlistment Option Report) are presumed to be correct. Approximately 17 percent of the USMC accession records were unusable because missing education codes prohibited high school graduate classification.

Q: Quality Population. The population variable is defined to be the non-prior service, diploma high school graduate, 17-21-year-old males classified in mental categories I-IIIA and not pursuing further schooling. Nationally, this subpopulation accounts for approximately 6 percent of the Military Available (MA) population. (The MA population is taken to be non-prior service, non-institutionalized, 17-21-year-old males.) Data for this variable were extracted from GRC estimates of Qualified Military

Available (QMA) population as of June 1976. (The QMA population is that segment of the MA population which is both physically and mentally qualified for military service.)

R: Recruiters on Station. The recruiter data used in this analysis were provided by USAREC with the concurrence of representatives of the individual Services. The data consist of estimates of production recruiters (including area captains) on station as of 31 October 1976. These are the only state-level estimates of recruiter strengths available.

U: Unemployment. Unemployment is a traditional measure of economic condition. In this analysis, the underlying economic data are extracted from Table D-4, "Total Unemployment and Unemployment Rates by State: Annual Averages, 1970-75" of the Employment and Training Report of the President, transmitted to the Congress, 1976. The data represent general unemployment as a percent of the labor force and were provided by state employment security agencies cooperating with the U.S. Department of Labor.

E: Reciprocal of Civilian Pay. In order to account for regional variation in economic attractiveness of military service as an alternative to civilian pursuits, the reciprocal of civilian pay was included in the model. The data for this variable were extracted from Table C-13, "Gross hours and earnings of production workers on manufacturing payrolls, by state and selected areas" of the Bureau of Labor Statistics publication, Employment and Earnings, for August 1976. The payroll data are for June 1976.

The justification for including regional variations in civilian pay scales in the analysis is based upon two considerations. First, it appears plausible that certain of the economic and career motivations for entering military service (e.g., learning a trade) are influenced by socioeconomic status. Secondly, the attractiveness of military pay is undoubtedly modified by prevailing civilian pay scales.

Since military pay is constant across region, a cross-sectional model cannot track its effect and hence military pay is not considered in this analysis. Customarily, when military pay appears in a time-series analysis, it is included as the ratio of military to civilian pay. It is this traditional treatment of civilian pay which led to the decision to include its reciprocal in the analysis.

Selection of a Functional Form

In accordance with the second guideline for model selection, the functional form chosen for the analysis is the multiplicative Cobb-Douglas form, viz,

$$N = e^{c}Q^{\varepsilon_q}R^{\varepsilon_r}U^{\varepsilon_u}E^{\varepsilon_e}$$

where N, Q, R, U and E are as defined above,

$e (\doteq 2.7183)$ is the base of the natural logarithms, and c, ε_q, ε_r, ε_u, ε_e are parameters to be determined by fitting the functional forms to the available data.

The parameters ε_q, ε_r, ε_u, ε_e are the elasticities of the associated variables. The elasticity is defined to be the percentage change induced in the dependent variable by a percent change in the associated independent variable (if, for example, the elasticity of population is equal to .5, a 10 percent change in Q would induce a 5 percent change in N).

The Cobb-Douglas form is chosen for the analysis primarily because of a property unique to it, viz, the elasticities computed from the model are invariant under simple scaling of the variables. This property may be illustrated by considering the following example. Suppose that Y can be expressed as a function of X in the following way:

$$Y = cX^{\varepsilon_x}$$

If the model is recast to write Y as a function of $Z = kX$ where k is a positive number, the property of invariant elasticities under scaling of the data means that the solution to the new model is

$$Y = c'Z^{\varepsilon_x}$$

where $c' = c/k^{\varepsilon_x}$. Although the value of the constant term is different for the two models, the elasticities for the scaled and unscaled variables are identical.

The impact of the property of invariant elasticity under scaling is important in view of the uncorrectable defects in the source data. Specifically,

- Although the accession data for the Army, Navy and Air Force are presumed to be reasonably complete and correct, 17 percent of the USMC accession records were unusable due to missing education codes. To the extent that the high school graduates represented by these records were proportionately distributed among the states, no distortion is induced in the elasticities arising from the Marine Corps model.

- With respect to the population variable Q, it is noted that if the "true market" for a service is proportional to Q, the elasticity computed for Q will be the "true market" elasticity for the service. Furthermore, the QMA data from which Q is developed is reported as of June 1976. The assumption that the 1975 QMA is proportional to the 1976 QMA is quite reasonable and thus the use of the Cobb-Douglas form prevents the difference in magnitudes from distorting the elasticity computed for Q.

- As stated in the definition of R, the only estimates of recruiter strengths by state are made as of 31 October 1976. To the extent that the distribution of recruiters among the states (1.4 percent of the recruiter force in Alabama, 10.6 percent in California, etc.) in CY75 coincides with the distribution as of 31 October 1976, the elasticity computed for R will be free from distortion.

- The overall unemployment rate U is intended as a measure of general economic condition. If a measure of more direct motivation to enlist were desired, the unemployment rate among the age and race groups of interest might be considered. To the extent that these specific unemployment rates are proportional to overall unemployment, the elasticity computed for U will be the elasticity for the specific rates.

- E is intended as a measure of regional economic opportunity in the civilian sector. Average earnings for production manufacturing workers were chosen for the computation of this variable but, as discussed above, any pay scale proportional (across states) to total manufacturing wages will yield an elasticity identical to that of E.

In light of the above discussion, it is evident that the property of invariant elasticities under scaling mitigates as far as possible the distortion effects of the uncorrectable defects in the source data and hence provides the Cobb-Douglas function with a robustness which is lacking in other (specifically linear) functional forms.

Methodological Considerations

The methodological price paid for the robustness of the Cobb-Douglas form is the loss of linearity. The customary treatment of this difficulty is to resort to a logarithmic transformation, viz,

Multiplicative model:

$$N = e^{c}\left(Q^{\varepsilon_q}\right)\left(R^{\varepsilon_r}\right)\left(U^{\varepsilon_u}\right)\left(E^{\varepsilon_e}\right)$$

Log-linear model:

$$\ln(N) = c + \varepsilon_q \ln(Q) + \varepsilon_r \ln(R) + \varepsilon_u \ln(U) + \varepsilon_e \ln(E)$$

where ln(X) represents the natural logarithm of X and all other terms are as defined above. Having constructed the log-linear model, the customary practice is to solve it for c, ε_q, ε_r, ε_u, ε_e using a standard linear regression package and take ε_q, ε_r, ε_u and ε_e to be the elasticities of the corresponding variables.

The above described approach is not correct. The problem lies in the unfortunate fact that since the logarithm is not a linear transformation, the solution of the log-linear model is not the solution of the multiplicative model. (This problem is discussed at some length in an article by W. A. Dotson in Appendix A.)

The methodology used in this study is to construct and solve the log-linear model in the ordinary way and then use the computed parameters as a starting point for the iterative solution of the multiplicative model. The computer routine used for the nonlinear solution is a Gauss-Marquardt least-squares algorithm written at the Computing Technology Center, Union Carbide Corp., Nuclear Division, Oak Ridge, Tennessee, by G. W. Wesley and modified at North Carolina State University by R. M. Felder.

- Remove statistically insignificant variables from the solution (i.e., constrain the associated elasticity to be zero) first singly and then in pairs until a model results in which all non-zero elasticities are statistically significant. This step yields the finalized models.

Preliminary Solutions (Log-linear vs Multiplicative)

The solution and associated R^2 for each of the log-linear models and for each of the preliminary multiplicative models are presented in Table 4.1.

The differences between the log-linear and multiplicative models are sometimes quite striking. Special attention is drawn to the significant differences between unemployment elasticities computed for non-whites in the Army and Navy models. These and other differences serve to illustrate the fact that approximate solutions, however time-honored, need not be very good approximations.

Finalized Solutions

Finalizing the supply models is a matter of assigning the statistically insignificant variables an elasticity of zero and resolving the model. This procedure effectively removes the non-significant variables from the supply equation. In the equations with two insignificant variables, models were considered where each of the variables was removed separately and where both variables were removed at once. This procedure guarantees that no statistically significant variable of the set under consideration was omitted because of noise arising from the presence of an insignificant variable.

The finalized supply models are presented in Table 4.2, along with the standard error for each elasticity.

DISCUSSION OF RESULTS

Population (QMA) and Recruiters

Examination of the correlation matrices of Appendix C reveals a high correlation between recruiters on station and QMA. Since QMA has historically been the basis for recruiter assignment, this correlation is not

Table 4.1

I-IIIA, DHSG ACCESSION SUPPLY ELASTICITIES ARISING FROM LOG-LINEAR MODEL (L) AND MULTIPLICATIVE MODEL (M)

		White		Non-white	
		L	M	L	M
Army	c	-1.19	4.50	16.24	22.41
	ϵ_q	.57	.65	.89	.41
	ϵ_r	.30	.34	.30	.54
	ϵ_u	.44	.34	.52	-.42
	ϵ_e	-.07*	1.16	3.73	4.11
	R^2	.9282	.9624	.5581	.7505
Navy	c	-1.24	3.50	6.80	7.02
	ϵ_q	.52	.44	.34	.35
	ϵ_r	.34	.56	.70	.63
	ϵ_u	.19	.03*	.17*	-.53
	ϵ_e	-.26	.61	1.49	1.18
	R^2	.9275	.9679	.8954	.9310
USAF	c	-.30	1.49	11.25	6.44
	ϵ_q	.54	.17	.78	.65
	ϵ_r	.40	.75	.48	.22
	ϵ_u	.50	.25	.17*	-.20*
	ϵ_e	.10*	-.11*	2.63	1.19
	R^2	.9318	.9496	.7340	.8767
USMC	c	-5.68	-1.30	12.52	5.61
	ϵ_q	.78	.53	.75	.56
	ϵ_r	.15	.40	.32	.27
	ϵ_u	.26	-.06*	.47	-.15*
	ϵ_e	-.61	-.18*	2.94	1.05
	R^2	.9322	.9583	.7399	.8251

---

*Indicates that the parameter is not statistically significant.

Table 4.2

FINALIZED SUPPLY MODELS FOR I-IIIA, DHSG ACCESSIONS

Parameter		White		Non-white	
		Value	Standard error	Value	Standard error
Army	c	4.50		22.41	
	ϵ_q	.65	.10	.41	.15
	ϵ_r	.34	.09	.54	.20
	ϵ_u	.34	.11	-.42	.41[a]
	ϵ_e	1.16	.24	4.11	.56
	R^2	.9624		.7505	
Navy	c	3.54		7.02	
	ϵ_q	.44	.07	.35	.08
	ϵ_r	.56	.06	.63	.08
	ϵ_u	-0-		-.53	.19
	ϵ_e	.61	.23	1.18	.32
	R^2	.9678		.9310	
USAF	c	1.85		5.99	
	ϵ_q	.20	.09	.64	.08
	ϵ_r	.73	.09	.21	.08
	ϵ_u	.25	.12	-0-	
	ϵ_e	-0-		1.17	.37
	R^2	.9495		.8755	
USMC	c	-.76		5.31	
	ϵ_q	.57	.09	.55	.10
	ϵ_r	.37	.08	.26	.10
	ϵ_u	-0-		-0-	
	ϵ_e	-0-		1.04	.45
	R^2	.9579		.8243	

[a] While this elasticity only just barely satisfies our condition for significance, the primary reason for not ignoring it is that the corresponding standard error for the regression against mental group I and II accession was only one-fourth as large for virtually the same value of ε_u.

surprising. Still, a question occurs as to the reliability with which the model discriminates between the effects of population and recruiters. To date, the theoretical development required to resolve this question in the case of the non-linear form of model chosen for the analysis has not been done. In the absence of a rigorous method of evaluating precisely how deleterious the large correlations are, the properties of the modeling results must be closely examined. To facilitate this examination, the finalized population and recruiter elasticities are summaried in Table 4.3.

Table 4.3

SUMMARY OF THE FINALIZED ELASTICITIES FOR POPULATION (ε_q) AND RECRUITERS (ε_r) BY RACE AND SERVICE

	White			Non-white		
Service	ε_q	ε_r	$\varepsilon_q+\varepsilon_r$	ε_q	ε_r	$\varepsilon_q+\varepsilon_r$
Army	.65	.34	.99	.41	.54	.95
Navy	.44	.56	1.00	.35	.63	.98
USAF	.20	.73	.93	.64	.21	.85
USMC	.57	.37	.94	.55	.26	.81

$\underline{\varepsilon_q+\varepsilon_r \approx 1.}$ The results show that for each of the eight models, the sum of the population and recruiting elasticities is very near unity. This result derives empirically from the nature of the data rather than from any constraint in the model. It can be taken, therefore, to be strong empirical support for an alternative formulation in which population and recruiting elasticities sum to unity by assumptions, i.e.,

$$\varepsilon_q + \varepsilon_r = 1.$$

Under this assumption the model

$$N = cQ^{\varepsilon_q} R^{\varepsilon_r} U^{\varepsilon_u} E^{\varepsilon_e}$$

can be rewritten as

$$(\frac{N}{R}) = c\ (\frac{Q}{R})^{\varepsilon_q} U^{\varepsilon_u} E^{\varepsilon_e}$$

where ε_q is the same for both formulations and where all other variables are as defined above. Thus, the empirically-derived assumption that population and recruiting elasticities sum to unity is equivalent to assuming a Cobb-Douglas form where the elasticity of population coverage $(\frac{\dot{Q}}{R})$ with respect to recruiter productivity $(\frac{N}{R})$ is ε_q. It is noteworthy that this alternate formulation eliminates the difficulty of a high correlation between recruiters and population.

Had this alternate formulation been employed at the outset, the resulting models would have (with few exceptions) been virtually identical to those summarized in Table 4.3.

<u>Results Not Unintuitive</u>. Since a time series approach was considered in Chapter 3 and rejected because of its unintuitive implications regarding population effects, the alternative model used in this analysis should be examined for the same shortcoming.

Presuming no change in other factors, if the recruitable population for a Service is saturated with recruiters (virtually every recruitable person is being contacted by a recruiter), then the size of the available population is the controlling factor and the addition of more recruiters can be expected to have little effect. This situation produces a high population elasticity and a low recruiter elasticity. On the other hand, if relatively few of the Service's recruitable population are being contacted, the addition of more recruiters can be expected to have almost a proportional effect whereas the effect of changing the recruitable population would be relatively small.

According to this simple model, the more attractive a service is (the larger its recruitable population), the smaller its population elasticity will be and the larger its recruiter elasticity will be. Similarly, the less attractive a service is, the larger its population elasticity will be and the smaller its recruiter elasticity will be. The population and recruiter elasticities shown in Table 4.3 do not appear to be badly at variance with either these expectations nor general recruiting experience. In the absence of other contradictory evidence, there seems to be no compelling reason to reject the population and recruiter elasticities arising from the cross-sectional supply models.

Unemployment

The unemployment variable used in this analysis is intended as a measure of the effect upon enlistments of the general economic condition. (A time-series analysis is required in order to address the direct, short-term impact of changes in unemployment rate.) It is presumed that areas with higher unemployment rates have fewer opportunities to offer in the civilian sector, and that consequently the alternative of military service is relatively more attractive than it is in areas where more civilian opportunities exist. Accordingly, one would expect ε_u to be non-negative.

With reference to the finalized supply models of Table 4.2, two facts are noteworthy:

Unemployment elasticities for whites are non-negative. The zero elasticities for the Navy and Marine Corps models mean that no evidence exists within the framework of these supply models to indicate that Navy and Marine Corps enlistments are much affected by regional variation in unemployment. The phenomenon suggests that white persons motivated by limited civilian opportunities prefer enlistment in the Army or Air Force to enlistment in the Navy or Marine Corps.

Unemployment elasticities for non-whites are non-positive. Again, zero elasticities for the Air Force and Marine Corps models suggest that regional economic condition is not an important motivation for non-white accessions to these services. The more significant result is the negative unemployment elasticities of the Navy (and, less strongly, the Army as well). In a time-series analysis, this phenomenon would indicate a substitution effect, i.e., during periods of high unemployment, white accessions are more readily available and are preferred (through policy considerations) to non-white accessions. The result is that fewer non-white accessions are produced than would be expected under the prevailing unemployment rate. This negative impact of high unemployment upon non-white enlistments (and the corresponding positive impact of low unemployment rates) results in a negative unemployment elasticity. Although this rationale may explain the negative values of ε_u for the Army and Navy models, certain objections arise:

- The cross-sectional model does not consider the effect of unemployment in different periods but rather the effect of unemployment in different regions. Consequently, it is conceivable that the effect of unemployment is being distorted by some regional phenomenon not otherwise accounted for by the model.

- In the light of the Services' quality requirements, if representational problems or other policy considerations were causing a substitution effect, it seems reasonable that the substitution would be of higher quality whites and non-whites for lower quality non-whites. This substitution mechanism would produce non-negative unemployment elasticities for the quality non-white enlistments under consideration.

- Because of the relatively small number of non-white accessions from some states and a corresponding small non-white population, the results of the non-white models may be distorted by sample size considerations. This possibility warrants further investigation.

If a substitution phenomenon such as described earlier for the hypothetical time series were operating in the Army and Navy, the effect in the cross-sectional model would presumably be just that which was observed. Nevertheless, it is illogical to conclude solely from these supply results that such a phenomenon is operating. The models indicate that for non-whites some external factor or factors are interfering with the ordinary supply mechanism. It is not possible to positively identify any such factors on the basis of this cross-sectional analysis.

Additional research is recommended on unemployment effects, including use of race-specific unemployment data as well as youth unemployment data, to supplement the present analysis which used overall unemployment data.

Compensation

The pay variable is included in the model to account for variation in the attractiveness of military pay due to differences in the civilian pay scale. In light of the historical fact that civilian wage opportunities for non-whites are substantially less than for whites, it is not surprising that this variable is substantially more important in the supply models for non-whites than it is in the white supply models. The fact that ε_e is significantly larger for the Army than for the other Services suggests that wage opportunity is a more significant factor in the enlistment decision for the Army than it is for the other Services. It should be noted, however, that ε_e says nothing in a direct way about the impact of military pay scales.

Developing the DOD Composite Supply Model

It is not possible, using the methodology employed in this study, to state categorically that the supply of volunteers to each Service is mutually exclusive. Obviously, there is considerable overlap in the recruiting market for each of the Services. This study does point out, however, that there are significant differences when the parameters of enlistment supply are examined by race. Based on this evidence, it was decided that forecasts of total enlistments should be derived by combining the separate estimates of the white and non-white supply models. To a lesser extent, the evidence also suggests that the quality enlistment supply to the individual Services is independent of each other, i.e., the degree of sensitivity of Navy enlistment supply to specific parameters is significantly different from the degree of sensitivity of Army enlistment supply to these same parameters.

Essentially, this means that it is not correct to combine all enlistment groups (both race- and Service-specific) and use this as the dependent variable in an attempt to forecast aggregate DOD enlistment supply. A more correct way is to estimate supply for each of the groups independently and then aggregate supply forecasts to obtain a DOD estimate.

While actual enlistment forecasts are derived in this manner, it may also be helpful to have aggregated elasticities and productivities of the various parameters used in the enlistment supply models. Table 4.2 displays the supply parameters computed independently by Service and race. Where elasticities are required that are not race-specific and/or Service-specific, these elasticities should be computed as a composite value of the race- and Service-specific elasticities, weighted by the proportion of enlistments obtained by race and Service. The method for computing these elasticities is demonstrated in the example on the following page.

Using this methodology, Table 4.4 shows the non-race-specific elasticities for each of the parameters by Service and for DOD, Let T = total enlistments,

W = white enlistments,

B = non-white enlistments,

ε_{r_T} = composite elasticity for recruiters without regard to race.

Then,

$$\varepsilon_{r_T} = \frac{\Delta T}{T} / \frac{\Delta R}{R} = \frac{\Delta T}{\Delta R} \cdot \frac{R}{T}$$

$$= \frac{\Delta W + \Delta B}{\Delta R} \cdot \frac{R}{T}$$

$$= \frac{\Delta W}{\Delta R} \cdot \frac{R}{T} + \frac{\Delta B}{\Delta R} \cdot \frac{R}{T}$$

$$= \frac{W}{W}\left(\frac{\Delta W}{\Delta R} \cdot \frac{R}{T}\right) + \frac{B}{B}\left(\frac{\Delta B}{\Delta R} \cdot \frac{R}{T}\right)$$

$$= \frac{W}{T}\left(\frac{\Delta W}{\Delta R} \cdot \frac{R}{W}\right) + \frac{B}{T}\left(\frac{\Delta B}{\Delta R} \cdot \frac{R}{B}\right)$$

$$= \frac{W}{T}\ \varepsilon_{r_w} + \frac{B}{T}\ \varepsilon_{r_b} .$$

For the Army models, the expression for composite recruiter elasticity evaluates as follows:

$$\varepsilon_{r_T} = \frac{47{,}848}{55{,}994}\,(.34) + \frac{8{,}146}{55{,}994}\,(.54)$$

$$= .856(.34) + 1.44(.54)$$

$$= .29 + .078 = \underline{.368}$$

Table 4.4

NON-RACE-SPECIFIC SUPPLY MODELS FOR I-IIIA DHSG ENLISTMENTS
(Values shown in the table represent elasticities)

Parameter	Army	Navy	Marine Corps	Air Force	DOD		
					White	Non-white	Total
Constant	7.11	3.81	.12	2.26	2.88	12.82	4.01
ε_q	.62	.43	.57	.24	.46	.47	.46
ε_r	.37	.57	.35	.68	.51	.44	.50
ε_u	.23	-.04	-0-	.23	.17	-.28	.12
ε_e	1.59	.65	.15	.12	.55	2.36	.76

While it is more nearly correct to forecast enlistments by race and Service and then aggregate the data to obtain a combined forecast, use of the elasticities shown on Table 4.4 will provide estimates comparable to the preferred approach. In a later chapter in this report, the composite recruiter elasticities are used to estimate the size of the accession budget required to offset projected declines in enlistments.

Chapter 5

ENLISTMENT PROJECTIONS

GENERAL

The forecasts of quality enlistments presented in this chapter are developed from the race-specific enlistment supply models summarized in Table 4.2 . The forecasts examine the effects of projected changes in populations and unemployment rates as documented by the Census Series II projections of the 17-21-year-old male populations by race[1] and the Congressional Budget Office (CBO) projections of unemployment rates[2].

RESULTS

Tables 5.1, 5.2 and 5.3 display the yearly changes in quality enlistments anticipated due to population shifts or CBO's projected decline in unemployment.

Table 5.1 displays the projected changes in supply, assuming CBO's October 1976 unemployment projections. This projection assumes no change in population. This unemployment projection was based upon a more optimistic outlook for improvements in the economy. CBO forecasted that unemployment would decline approximately 52 percent and reach a 4 percent level by 1983.

Table 5.2 displays the expected changes in enlistments, assuming CBO's January 1977 unemployment projections. Under this projection, CBO forecasts a more gradual recovery in the economy and a general unemployment decline by some 45 percent by 1983. Note that the budget analysis conducted in this report uses CBO's January unemployment projections. The enlistment projections using the October 1976 CBO forecast are included here for comparison purposes only.

---

[1] Current Population Reports, series P-25, No. 601, Bureau of the Census, October 1975.

[2] "The Costs of Defense Manpower: Issues for 1977," Budget issue paper prepared by the Congressional Budget Office, January 1977, Tables A-1 and A-2.

Table 5.1

PROJECTED CUMULATIVE PERCENT CHANGES IN I-IIIA, DHSG ACCESSIONS BY RACE AND SERVICE UNDER OCTOBER 76 UNEMPLOYMENT PROJECTIONS

	ARMY		NAVY		USAF		USMC	
	White	Non-white	White	Non-white	White	Non-white	White	Non-white
1976	-.0238	+.0294	-0-	+.0371	-.0175	-0-	-0-	-0-
1977	-.0578	+.0714	-0-	+.0901	-.0425	-0-	-0-	-0-
1978	-.0918	+.1134	-0-	+.1431	-.0675	-0-	-0-	-0-
1979	-.1190	+.1470	-0-	+.1855	-.0875	-0-	-0-	-0-
1980	-.1428	+.1764	-0-	+.2226	-.1050	-0-	-0-	-0-
1981	-.1564	+.1932	-0-	+.2438	-.1150	-0-	-0-	-0-
1982	-.1700	+.2100	-0-	+.2650	-.1250	-0-	-0-	-0-
1983	-.1768	+.2184	-0-	+.2756	-.1300	-0-	-0-	-0-
1984	-.1768	+.2184	-0-	+.2756	-.1300	-0-	-0-	-0-
1985	-.1768	+.2184	-0-	+.2756	-.1300	-0-	-0-	-0-
1986	-.1768	+.2184	-0-	+.2756	-.1300	-0-	-0-	-0-

PROJECTED CUMULATIVE CHANGE IN I-IIIA, DHSG ACCESSIONS BY RACE AND SERVICE UNDER OCTOBER 76 UNEMPLOYMENT PROJECTIONS

	ARMY			NAVY			USAF			USMC		
	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	-1139	+ 239	- 900	-0-	+ 153	+ 153	- 697	-0-	- 697	-0-	-0-	-0-
1977	-2766	+ 582	-2284	-0-	+ 371	+ 371	-1693	-0-	-1693	-0-	-0-	-0-
1978	-4393	+ 924	-3469	-0-	+ 589	+ 589	-2689	-0-	-2689	-0-	-0-	-0-
1979	-5694	+1197	-4497	-0-	+ 764	+ 764	-3485	-0-	-3485	-0-	-0-	-0-
1980	-5833	+1437	-4396	-0-	+ 917	+ 917	-4182	-0-	-4182	-0-	-0-	-0-
1981	-7484	+1574	-5910	-0-	+1004	+1004	-4581	-0-	-4581	-0-	-0-	-0-
1982	-8134	+1711	-6423	-0-	+1091	+1091	-4979	-0-	-4979	-0-	-0-	-0-
1983	-8460	+1779	-6681	-0-	+1135	+1135	-5178	-0-	-5178	-0-	-0-	-0-
1984	-8460	+1779	-6681	-0-	+1135	+1135	-5178	-0-	-5178	-0-	-0-	-0-
1985	-8460	+1779	-6681	-0-	+1135	+1135	-5178	-0-	-5178	-0-	-0-	-0-
1986	-8460	+1779	-6681	-0-	+1135	+1135	-5178	-0-	-5178	-0-	-0-	-0-

Table 5.2

Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions by Race and Service Under January 77 Unemployment Projection

	ARMY		NAVY		USAF		USMC	
	White	Non-White	White	Non-White	White	Non-White	White	Non-White
1976	.0000	+.0000	-0-	.0000	.0000	-0-	-0-	-0-
1977	-.0238	+.0294	-0-	+.0371	-.0175	-0-	-0-	-0-
1978	-.0442	+.0546	-0-	+.0689	-.0325	-0-	-0-	-0-
1979	-.0578	+.0714	-0-	+.0901	-.0425	-0-	-0-	-0-
1980	-.0850	+.1050	-0-	+.1325	-.0625	-0-	-0-	-0-
1981	-.1088	+.1344	-0-	+.1696	-.0800	-0-	-0-	-0-
1982	-.1326	+.1638	-0-	+.1802	-.0850	-0-	-0-	-0-
1983	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1984	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1985	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-
1986	-.1530	+.1890	-0-	+.2385	-.1125	-0-	-0-	-0-

Projected Cumulative Change in I-IIIA, DHSG Accessions by Race and Service Under January 77 Unemployment Projections

	ARMY			NAVY			USAF			USMC		
	White	Non-White	Total	White	Non-White	Total	White	Non-White	Total	White	Non-White	Total
1976	0	0	0	-0-	0	0	0	-0-	0	-0-	-0-	-0-
1977	-1139	+ 239	- 900	-0-	+153	+153	- 697	-0-	- 697	-0-	-0-	-0-
1978	-2115	+ 445	-1670	-0-	+284	+284	-1295	-0-	-1295	-0-	-0-	-0-
1979	-2766	+ 582	-2184	-0-	+371	+371	-1693	-0-	-1693	-0-	-0-	-0-
1980	-4067	+ 855	-3212	-0-	+546	+546	-2489	-0-	-2489	-0-	-0-	-0-
1981	-5206	+1095	-4111	-0-	+698	+698	-3186	-0-	-3186	-0-	-0-	-0-
1982	-6345	+1334	-5011	-0-	+742	+742	-3386	-0-	-3386	-0-	-0-	-0-
1983	-7321	+1540	-5781	-0-	+982	+982	-4481	-0-	-4481	-0-	-0-	-0-
1984	-7321	+1540	-5781	-0-	+982	+982	-4481	-0-	-4481	-0-	-0-	-0-
1985	-7321	+1540	-5781	-0-	+982	+982	-4481	-0-	-4481	-0-	-0-	-0-
1986	-7321	+1540	-5781	-0-	+982	+982	-4481	-0-	-4481	-0-	-0-	-0-

Table 5.3

Projected Cumulative Percent Changes in I-IIIA, DHSG Accessions Due to Population by Race and Service

	ARMY		NAVY		USAF		USMC	
	White	Non-white	White	Non-white	White	Non-white	White	Non-white
1976	+.00650	+.01230	+.00440	+.01050	+.00200	+.01920	+.00570	+.01650
1977	+.01040	+.02132	+.00700	+.01820	+.00320	+.03328	+.00912	+.02860
1978	+.01560	+.02911	+.01056	+.02485	+.00480	+.04544	+.01368	+.03905
1979	+.01300	+.03362	+.00880	+.02870	+.00400	+.05248	+.01140	+.04510
1980	+.00845	+.03813	+.00572	+.03255	+.00260	+.05952	+.00741	+.05115
1981	+.00260	+.04100	+.00176	+.03500	+.00080	+.06400	+.00228	+.05500
1982	-.00910	+.04223	-.00616	+.03605	-.00280	+.06592	-.00798	+.05665
1983	-.06175	+.03977	-.04180	+.03395	-.01900	+.06208	-.05415	+.05335
1984	-.08320	+.03321	-.05632	+.02835	-.02560	+.05184	-.07296	+.04455
1985	-.10595	+.02624	-.07172	+.02240	-.03260	+.04096	-.09291	+.03520
1986	-.12610	+.02132	-.08536	+.01820	-.03880	+.03328	-.11058	+.02860

Projected I-IIIA, DHSG Accessions Under Population Changes by Race and Service

	ARMY			NAVY			USAF			USMC		
	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	48160	8246	56406	48343	4161	52504	39911	4469	44380	19068	3287	22355
1977	48346	8320	56666	48468	4193	52661	39958	4531	44489	19133	3326	22459
1978	48595	8383	56978	48639	4220	52859	40022	4584	44606	19219	3360	22579
1979	48471	8420	56891	48555	4236	52791	39990	4615	44605	19176	3380	22556
1980	48253	8457	56710	48406	4252	52658	39935	4646	44581	19100	3399	22499
1981	47973	8480	56453	48216	4262	52478	39863	4666	44529	19003	3412	22415
1982	47414	8490	55904	47835	4266	52101	39719	4674	44393	18809	3417	22226
1983	44894	8470	53364	46119	4258	50377	39074	4657	43831	17933	3407	21340
1984	43868	8417	52285	45420	4235	49655	38811	4612	43423	17577	3378	20955
1985	42779	8360	51139	44679	4210	48889	38533	4565	43098	17198	3348	20546
1986	41815	8320	50135	44023	4193	48216	38286	4531	42817	16863	3326	20189

In examining Table 5.2, it is apparent that, based on the supply models developed in Chapter 4, no unemployment effects for this quality class were detected for the Marine Corps. Significant unemployment effects were found for both whites and non-whites in the case of the Army supply model only. In the case of Army white enlistments, a decline of up to 15 percent is expected by 1983. In contrast, Army non-white enlistments should rise by 19 percent in 1983. Numerically, this amounts to 7300 white enlistments lost and 1500 non-white enlistments gained by the Army by 1983. With respect to the Navy, no change in white enlistments is anticipated since the model did not detect a significant unemployment effect for this quality class. Non-white enlistments were expected to increase by some 24 percent by 1983. The numerical increase, however, is rather small — less than 1000 additional enlistments. For the Air Force, white enlistments are expected to decrease slightly more than 11 percent by 1983, or a numerical decline of approximately 4500 enlistments. No decrease in non-white enlistments is projected.

Table 5.3 displays the projections due to anticipated changes in the population of 17-21-year-old males. This projection assumes no change in unemployment. Note that based on census population forecasts and the results of the supply model developed in Chapter 4, declines in enlistments for this quality class are anticipated for white males only. This decline does not actually begin until 1982. If these assumptions are correct, non-white enlistments in the preferred quality class will continue to rise for all Services.

Of the four Services, the Army is most sensitive to changes in population. By 1986, Army white enlistments should be 13 percent below the CY 1975 estimates; thus, white enlistments will decline from approximately 48,000 to 42,000. Because a slight increase in non-white enlistments is anticipated, the net decline for this quality enlistment group is expected to be slightly more than 11 percent by 1986.

The Census projections also show that the white male population will continue to decline through the 1990's. The trough of this decline is expected to be in 1993 when the white male population of those 17-21-years old will be 32 percent below the level for 1975. Should the QMA of this group decline proportionately, the elasticities developed in Chapter 4 would project a 21 percent decline in Army white enlistments in the preferred quality class. The other Services would also experience declines, although to a lesser degree in both relative and absolute terms.

GRC has assumed that there is a proportional relationship between annual changes in the 17-21-year-old male population and male QMAs of this age group who are also diploma high school graduates and in mental groups I-IIIA.

In evaluating current and future enlistment potential, the size of the QMA market is an important consideration; for example, Table 5.4 displays QMA and enlistment data to produce a measure of market penetration achieved by the Services. Overall, the Services are recruiting about 9 percent of the diploma high school graduate QMA market (mental groups I-IV). While 9 percent may not appear to be a sizable proportion of the total market, when disaggregated by race and mental group, significant differences in market penetration do appear. For example, with respect to the non-white, I-IIIA QMA market, almost 47 percent of that market is already enlisting in the military. In contrast, the proportion of the white I-IIIA QMA market enlisting is approximately 9 percent, or less than one-fifth the rate of enlistment when compared to non-whites. Results such as these are consistent with survey data which show significant differences in preference for the military when the data are examined by race. More important, however, is the fact that the Services are already recruiting a very sizable share of the non-white enlistment market. Unless there are dramatic improvements in the mental group distribution or high school completion rates of minorities, it is unrealistic to expect a substantial increase in non-white enlistments in the future in spite of the fact that the population for this group will continue to grow through the 1980's. This conclusion, however, should be tempered with the following considerations. First, while the non-white QMA market amounts to less than 200,000 in total, over three-fourths of this group fall into mental groups IIIB and IV (Figure 5.1). Presumably, the lower market penetration for these non-whites is due to the enlistment qualification standards currently in effect. Should the Services find themselves in the position of needing more high school graduates in the future, a decision

Table 5.4

RECRUITING MARKET PENETRATION

	(1) Diploma high school graduate QMA market	(2) DOD Male DHSG enlistments (CY75)	(2÷1) Market penetration (percent)
White	2,575,506	205,253	8.0
I, II	1,322,366	97,409	7.4
IIIA	486,084	57,362	11.8
IIIB	462,233	42,665	9.2
IV	304,823	7,817	2.6
Non-white	198,894	45,535	22.9
I, II	19,871	7,761	39.1
IIIA	22,639	12,122	53.5
IIIB	56,417	19,412	34.4
IV	99,967	6,240	6.2

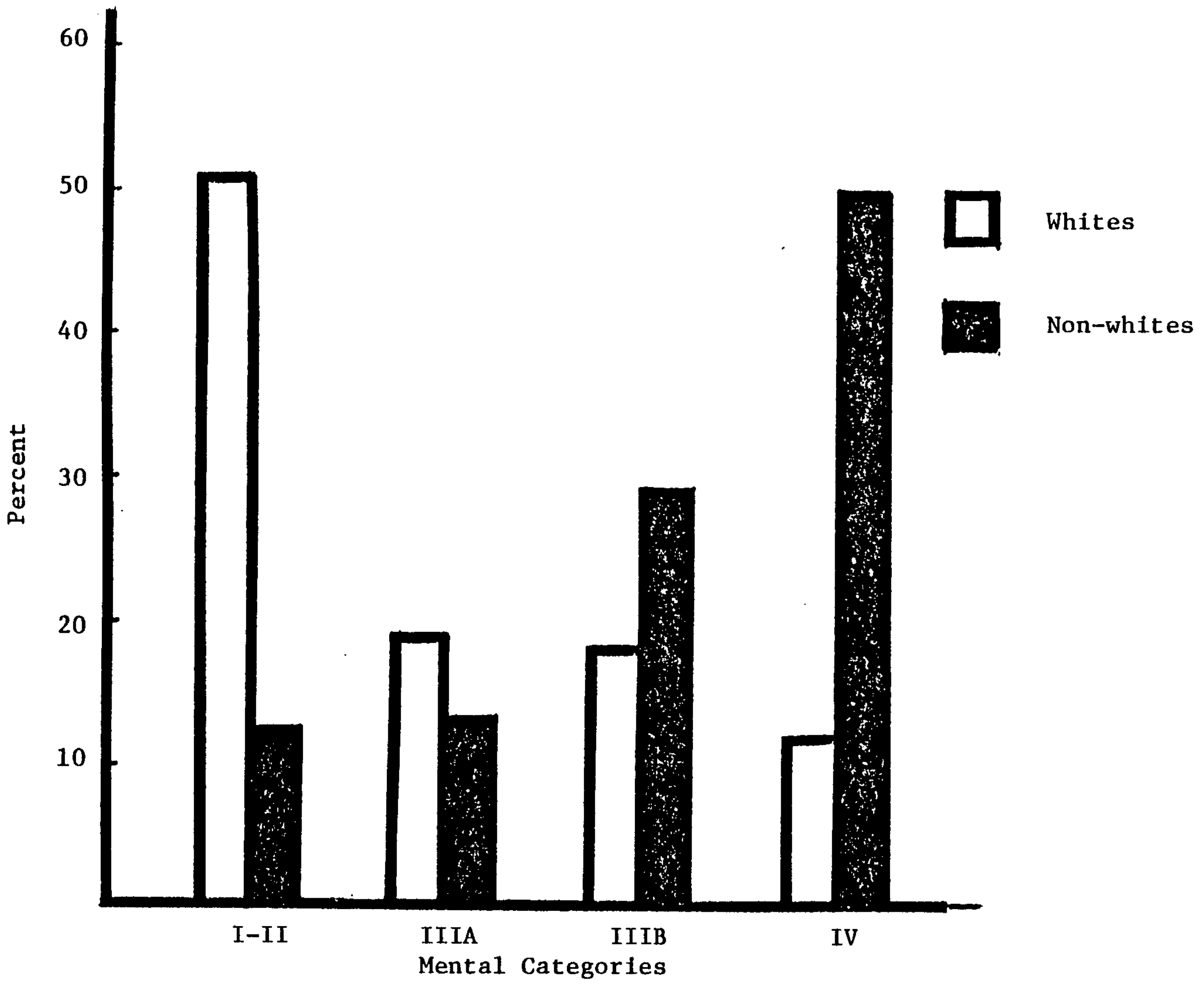

Fig. 5.1—17-21-year-old QMA Male High-School Graduates Mental Group Distribution by Base

to recruit from the lower mental groups would substantially increase minority enlistments; for example, if administrative controls on recruiting IIIB QMAs were dropped, a proportion of minority QMAs recruited from this group would likely rise from the current 34 percent. This action alone could bring in an additional 7,000 male high school graduate enlistments, which would almost equal the projected decline in white high school graduate enlistments in mental groups I-IIIA due to population changes through 1986.

Additionally, both the QMA and the Census population projections are subject to sampling error. Baseline data used in the QMA projections are Census population data and, therefore, to the extent that Census population data are inaccurate, similar inaccuracies will have crept into the QMA data. One criticism that has been raised regarding Census data is the potential undercount of minority populations during the 1970 census. Indirect estimates of the current minority populations suggest that the undercount is of a magnitude approaching 10 percent. If an undercount exists, then projected minority recruitment in the future is understated.

Table 5.5 displays the numerical projections arising from the analysis. Base supply estimates are CY 1975 actual counts and are displayed on Table 5.6. This table also shows enlistment counts for lower mental group personnel, as well as data on the QMA market.

It is important to keep in mind that the projections shown in Table 5.5 assume no change in other factors relevant to the accession process; specifically, the number of recruiters and the pay relationships across regions are assumed to be constant through all projection years. Using CBO's January unemployment projections, Army male high school graduate enlistments in mental groups I-IIIA are projected to decline by nearly 21 percent over the period CY 1975-1986. In CY 1975, 15 percent of this group were non-white. Due to the fact that the non-white population is not expected to decline but actually increase slightly, and the fact that the forecasting model shows an inverse relationship between unemployment declines and enlistment results for non-whites, this proportion is expected to increase to 22 percent by CY 1986. These projections on aggregate enlistments and minority composition are summarized on Table 5.7.

Table 5.5

Projected I-IIIA DHSG Accessions Under Projected Population and Unemployment Changes, by Race and Services for October 1976 and January 1977 Unemployment Projections

October 1976 Projection

	ARMY			NAVY			USAF			USMC		
	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	47021	8485	55506	48343	4314	52657	39214	4469	43683	19068	3287	22355
1977	45580	8902	54382	48468	4564	53032	38265	4531	42796	19133	3326	22459
1978	44202	9307	53509	48639	4809	53448	37333	4584	41917	19219	3360	22579
1979	42777	9617	52394	48555	5000	53555	36505	4615	41120	19176	3380	22556
1980	42420	9894	52314	48406	5169	53575	35753	4646	40399	19100	3399	22499
1981	40489	10054	50543	48216	5266	53482	35282	4666	39948	19003	3412	22415
1982	39280	10201	49481	47835	5357	53192	34740	4674	39414	18809	3417	22226
1983	36434	10249	46683	46119	5393	51512	33896	4657	38653	17933	3407	21340
1984	35408	10196	45604	45420	5370	50790	33633	4612	38245	17577	3378	20955
1985	34319	10139	44458	44679	5345	50024	33355	4565	37920	17198	3348	20546
1986	33355	10099	43454	44023	5328	49351	33108	4531	37639	16863	3326	20189

January 1977 Projection

	ARMY			NAVY			USAF			USMC		
	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total	White	Non-white	Total
1976	48160	8246	56406	48343	4161	52504	39911	4469	44380	19068	3287	22355
1977	47207	8559	55766	48468	4346	52814	39261	4531	43792	19133	3326	22459
1978	46480	8828	55308	48639	4504	53143	38727	4584	43311	19219	3360	22579
1979	45705	9002	54707	48555	4607	53162	38297	4615	42912	19176	3380	22556
1980	44186	9312	53498	48406	4798	53204	37446	4646	42092	19100	3399	22499
1981	42767	9575	52342	48216	4960	53176	36677	4666	41343	19003	3412	22415
1982	41069	9824	50893	47835	5008	52843	36333	4674	41007	18809	3417	22226
1983	37573	10010	47583	46119	5240	51359	34593	4657	39350	17933	3407	21340
1984	36547	9957	46504	45420	5217	50637	34330	4612	38942	17577	3378	20955
1985	35458	9900	45358	44679	5192	49871	34052	4565	38617	17198	3348	20546
1986	34494	9860	44354	44023	5175	49198	33805	4531	38336	16863	3326	20189

Table 5.6

SUMMARY ENLISTMENT/QMA DATA

CY 1975

NPS Male Diploma Graduates

	White				Non-white				
	1,2	3A	3B	4	1,2	3A	3B	4	TOTAL
Army									
Accessions	31,043	16,806	15,779	3,838	2,899	5,247	11,675	4,804	92,091
Percent of total	34	18	17	4	3	6	13	5	100
Navy									
Accessions	30,334	17,797	11,176	2,921	1,742	2,376	2,744	1,031	70,121
Percent of total	43	25	16	4	3	3	4	2	100
USMC									
Accessions	11,504	7,456	5,847	595	1,416	1,818	2,265	310	31,211
Percent of total	37	24	19	2	5	6	7	1	100
USAF									
Accessions	24,528	15,303	9,863	463	1,704	2,681	2,728	95	57,365
Percent of total	42	27	17	1	3	5	5	a/	100
DOD									
Accessions	97,409	57,362	42,665	7,817	7,761	12,122	19,412	6,240	250,788
Percent of total	39	23	17	3	3	5	8	2	100
QMA b/									
Population	1,322,366	486,084	462,233	304,823	19,871	22,689	56,417	99,967	2,774,450
Percent of total	48	18	17	11	1	1	2	4	100 c/

---

a/ Less than 0.5%.

b/ QMA includes all 17-21-year-old, diploma high school graduate non-prior service males who are qualified for military service.

c/ Percentages may not sum to 100 due to rounding.

Table 5.7

SUMMARY OF I-IIIA DHSG ENLISTMENT PROJECTIONS USING THE JANUARY '77 CBO UNEMPLOYMENT PROJECTIONS

	Army		Navy		Marine Corps		Air Force	
	Total	% Non-white	Total	% Non-white	Total	% Non-white	Total	% Non-white
1975 (actual)	55,995	14	52,249	8	22,194	14	44,216	10
1978	55,308	16	53,143	8	22,579	15	43,311	11
1982	50,893	19	52,843	10	22,226	15	41,007	11
1986	44,354	22	49,198	12	20,546	16	38,617	12
% 1975-86	-21%	--	-6%	--	-7%	--	-13%	--

Chapter 6

ACCESSION BUDGET IMPLICATIONS OF THE ENLISTMENT SUPPLY FORECASTS

GENERAL

The purpose of this chapter is to estimate what the potential cost would be to overcome the projected shortfalls displayed on Table 5.7 through increases in the services' accession budgets. The accession budgets include three components — recruiters, advertising media, and recruiter aides. The purpose of including a chapter in this study on the accession budget implications of the enlistment forecasts is to show what the potential cost would be if the present course of action is continued in the face of a smaller enlistable market. While no specific budget recommendations can be made solely on the basis of these results, the data should be of assistance to defense manpower policy analysts whose responsibility it is to choose the most cost-effective management options available to sustain an AVF.

METHODOLOGY

In order to estimate the budgetary implications of the enlistment shortfalls, an optimal budget allocation model has been employed. This model was developed under previous contract work for Department of the Army and Office Secretary of Defense.[1/] Two fundamental assumptions are implicit in the modelling methodology. The first is that the programs employed diminish in effectiveness at an exponential rate and, at some point, provide no additional enlistments for each increment in the budget. The second assumption is that the various accession programs, such as recruiters, advertising media, and recruiter aides, are to some extent substitutes for one another. In the analysis in this chapter, the multiplicative exponential form[1/] is assumed in the optimization. The algorithm allocates funds among the competing programs in a manner that will

---

[1/] Documentation Report to Support the Analysis for Management of Recruiting Resources and Operations (AMRRO) System, General Rearch Corporation, CR-189, June 1977.

maximize the number of additional enlistments obtained from a specific dollar increment to the total accession budget.

The first step in using the model is to select a set of program elasticities and convert these into marginal products. These data are shown on Table 6.1 below.

Table 6.1

ACCESSION PROGRAM ELASTICITIES

	Army	Navy	Marine Corps	Air Force
Recruiters	.37	.57	.35	.68
Advertising media	.06	.06	.06	.06
Recruiter aides	.80	.80	.80	.80

These are the elasticities assumed to be in effect at CY 1975 enlistment supply levels. The only elasticities empirically derived from this study are the recruiter elasticities. These are the non-race-specific composite elasticities computed in Chapter 4 and displayed on Table 4.4. The advertising media elasticities were taken from a similar econometric study produced by GRC in 1974.[2/] These measurements, while admittedly crude, are the best estimates available on the direct effect advertising has on enlistment supply. The recruiter aide elasticities were not empirically derived but they are based on the assumption that each person-year of recruiter aide support produces 12 additional quality enlistments. These assumptions were made by OSD(MRA&L) staff based on results experienced with the Army's recruiter canvasser program. While both the advertising media and recruiter aide programs are important, test simulations using the budget model developed by GRC show that the recruiter budget was the most essential component of the forecasts. The recruiter elasticities used here rest on a much more solid framework of analysis.

[2/] Grissmer, D., et al., "An Econometric Analysis of Volunteer Enlistments by Service and Cost Comparison of Service Incentive Programs," OAD-CR-66, General Research Corporation, October 1974.

The elasticities shown on the previous table do not represent direct input into the model. Rather, they are used to compute marginal program productivities that are used as input to the model. In order to compute these program productivities, it is necessary to estimate the size of each component of the services' accession budgets. The budgets that were associated with CY 1975 enlistment supply levels are shown on the following table.

Table 6.2

SELECTED ACCESSION PROGRAM BUDGETS SUPPORTING CY 1975 ENLISTMENT SUPPLY LEVELS
($ millions)

	Army	Navy	Marine Corps	Air Force	Total
Recruiters	129.2	92.1	37.3	46.8	305.4
Advertising media	33.4	16.8	8.8	9.7	68.7
Recruiter aides	2.1	2.1	2.1	.1	6.4
Total	164.7	111.0	48.2	56.6	380.5

The data shown on this table exclude certain items that would normally be considered part of the accession budget. These are: enlistment bonuses, non-media advertising, the DOD marketing fund, lease of recruiting stations, AFEES operations, and leased housing for recruiters.

The purpose of this analysis is to determine what additions to the accession budget would be required to compensate for the lost enlistments due to population and unemployment declines. It would be useful to have an estimate of the proportion of the budgets that vary with enlistment workload. For purposes of this study, it is assumed that the advertising media and recruiter aides budgets shown on Table 6.2 are entirely variable. On the other hand, it is likely that there is some fixed component for the production recruiter budget that would not be expected to vary over a reasonable range of alternative enlistment levels and numbers of production recruiters. This analysis assumes that 65 percent of the recruiter budget, shown on Table 6.2, represents the variable component. This proportion is based on another study conducted by GRC in 1974.[3]

---

[3] Ibid.

In line with this reasoning, the following table shows the method used for computing marginal production rate for recruiters.

Table 6.3

MARGINAL PRODUCTION RATES FOR RECRUITERS

	Army	Navy	Marine Corps	Air Force
1. Recruiter budgets	$129.2M̄	$92.1M̄	$37.3M̄	$46.8M̄
2. Variable portion ((1)X.65)	$ 83.9M̄	59.9M̄	24.2M̄	30.4M̄
3. CY'75 Recruiter MY	4,822	3,515	1,818	1,820
4. Variable cost per MY ((2)÷(3))	$ 17,400	$17,000	$13,300	$16,700
5. Recruiter elasticities	.37	.57	.35	.68
6. CY'75 Supply (I-IIIA HSG)	56,000	52,200	22,200	44,200
7. Marginal products ((5) X(6)÷(3))	4.3	8.5	4.3	16.5
8. Marginal cost ((4)÷(7))	$ 4,046	$ 2,000	$ 3,100	$ 1,012
9. Production per million $ ($1.0M̄ ÷ (8))	247	500	322	988

The last line shows the number of additional quality enlistments that can be obtained for the next one million dollars invested in production recruiters for each Service at the base point, i.e., at CY 1975 accession levels and expenditures. These four values plus similar figures for recruiter aides and advertising media are input to the budget model and act as a starting basis to project accession budget costs at various enlistment levels.

RESULTS FROM THE BUDGET MODEL

Based on output from the optimal budget allocation model, Fig. 6.1 displays a series of accession budget production functions. The numbers annotated on each curve represent the marginal accession costs of recruiting the next additional quality enlistment at CY 1975 supply levels. In interpreting the figure, it is important to understand that each curve represents the relative responsiveness of the quality enlistable market

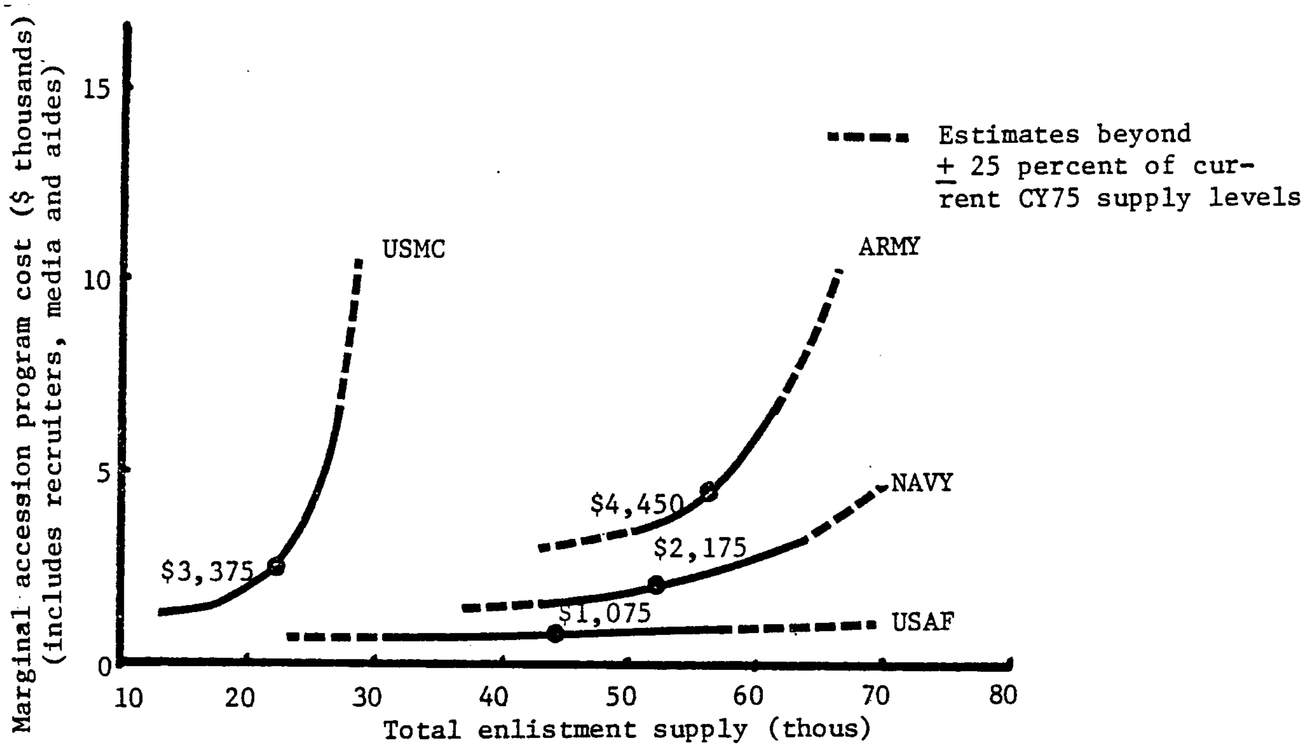

Fig. 6.1—Accession Production Functions NPS Male, DHSG, I-IIIA (at CY 75 supply levels)

to changes in the accession resources under CY 1975 wage, unemployment and population conditions. Thus, if any one Service wishes to increase the number of enlistments it was obtaining from the enlistable market in CY 1975 and chose to do so by expanding its accession budget, it would operate along the curves displayed on Fig. 6.1. For example, if the Army decided it was necessary to increase the number of quality enlistments in CY 1975 from 56,000 to 67,000, for an increase of 20 percent, an approximate 50 percent increase in the accession budget would be required (i.e., from 165 million to 245 million). At that level, the cost of the next additional quality enlistment would be $26,000. This example is intended to show that increasing the degree of market penetration experienced by each Service solely by additions to the accession budget can be very costly, and certainly other alternatives should be explored.

It is critical in interpreting the analysis discussed in this chapter to distinguish between a *shift* in a production function and a *movement along* a production function. The previous example showed the cost that would occur as the Army moves along its production function curve to increase its market penetration at CY 1975 enlistment supply levels.

The enlistment supply forecast described in Chapter 4 actually represents shifts in the supply curve each Service faces. Thus, changes in population and unemployment result in a shift of the production function as exemplified on Figure 6.2.

This figure shows schematically the magnitude and the shift in the production function that should occur when the supply of the enlistable market is reduced by declines in unemployment and population through projected CY 1986 level. The curve labelled I is essentially an expanded version of the CY 1975 Army production function curve. This is the production function the Army operated on when CY 1975 population and unemployment conditions were in effect. The slope of the curve at Point A ($4,450 per accession) is the marginal cost of recruiting the next additional quality enlistment under CY 1975 resource levels.

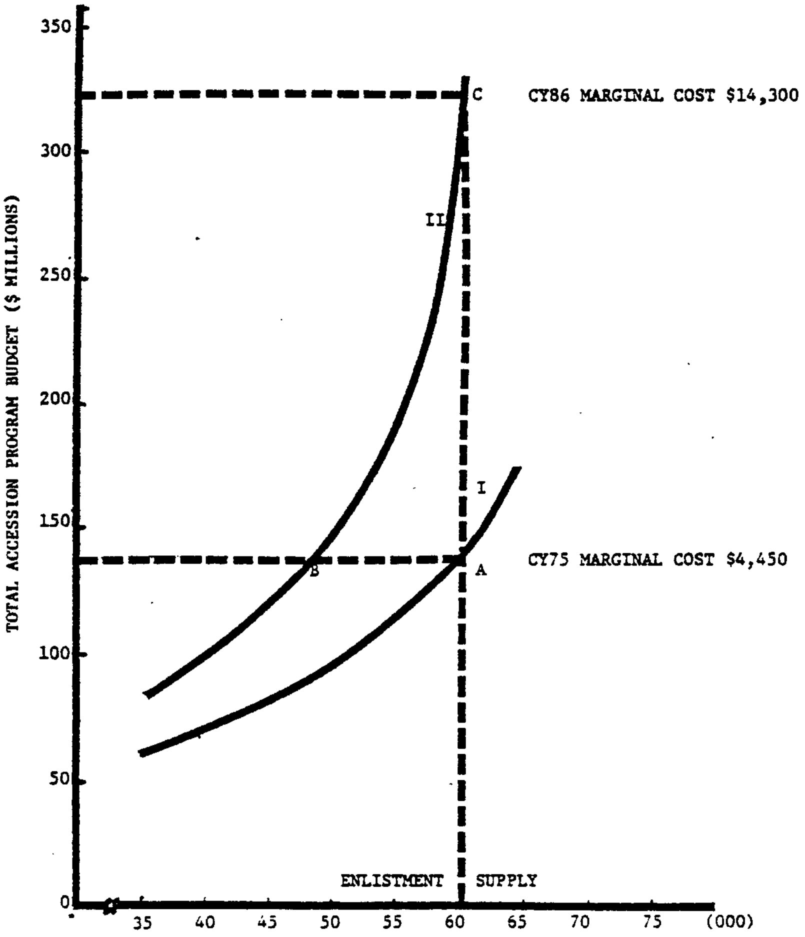

Fig. 6.2—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

The curve labelled II is the anticipated production function the Army will face at CY 1986 enlistment supply levels. Assuming no change in the accession budget beyond that established in CY 1975, Point B shows that the Army can anticipate recruiting 21 percent fewer quality enlistments should it decide (or be forced) to maintain a status quo in its accession budget. Should the Army wish to restore the total number of enlistments lost to the population and unemployment decline, it will have to increase its accession budget along production function II up to Point C. At that point it will have achieved the same number of enlistments it realized in CY 1975, but the marginal cost of the next additional enlistment is approximately three times larger than it was under CY 1975 conditions. Attaining Point C requires a $90 million or 56 percent increase in the annual accession budget over the 10-year period.

Hopefully, with some understanding of the budget implications of these shifts in the supply of quality enlistments, the results displayed on Table 6.4 should become more meaningful.

Table 6.4

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
FROM CY 1975 LEVEL

ARMY

	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY 75 Levels (Millions CY'75 $)	Average Cost Per Enlistment (CY'75 $)	Marginal Cost per Enlistment (CY'75 $)
CY 1975 Actual	56,000	$ 160.	$ 2,860	$ 4,450
CY 1978	(2,500)	175.	3,125	5,700
CY 1982	(6,500)	190.	3,400	6,900
CY 1986	(12,500)	250.	4,460	14,300

The data on the table show for three points in time beyond CY 1975 the anticipated quality enlistment shortfalls and the accession budget implications should the Army attempt to compensate for these shortages by increasing its budget to enlarge its market penetration. Each row on the table essentially represents a shift in the production function resulting from a reduced supply should population and unemployment decline as projected. Essentially, the table shows that by CY 1986 the Army would have to increase its accession budget by 60 percent to compensate for the 21 percent shrinkage in enlistment supply which will, in effect, triple the marginal cost of bringing in the next additional quality enlistment.

Accession budget results for the Navy are shown on the following table.

Table 6.5

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
FROM CY 1975 LEVEL

NAVY

	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 Levels (Millions CY'75 $)	Average Cost Per Enlistment (CY'75 $)	Marginal Cost per Enlistment (CY'75 $)
CY 1975 Actual	52,249	$ 111.0	$ 2,125	$ 2,175
CY 1978	+ 894	107.5	2,060	2,100
CY 1982	+ 594	108.0	2,070	2,100
CY 1986	(3,051)	115.0	2,200	2,350

Unlike the Army, the Navy faces a much less serious problem should it attempt to compensate for projected enlistment shortages through increases in its accession budget. Overall, the results show that if the Navy is required to maintain a status quo in the level of its accession budget, no significant decline in quality enlistments would occur. There are primarily two reasons for this. First, at the margin, the Navy is almost twice as productive as the Army with respect to the recruitment of quality enlistments. Thus, each increment in the accession budget will produce for the Navy twice as many enlistments. Second, results from the econometric analysis conducted in Chapter 4 show that Navy quality enlistments are not sensitive to changes in unemployment rates and, therefore, the only decline in enlistments anticipated in this study is due to eventual declines in the population.

Like the Navy, the Marine Corps faces a very similar situation. The results in the study show that unemployment is not a factor in forecasting quality enlistments for the Marine Corps and, while its marginal productivity of recruiters approximates that of the Army, increases in the accession budget are required only to offset declines due to population. This is shown on Table 6.6.

Table 6.6

CHANGE IN ACCESSION BUDGET TO OVERCOME
PROJECTED DECLINE IN NPS MALE DHSG I-IIIA
FROM CY 1975 LEVEL

MARINE CORPS

	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 levels (Millions CY'75 $)	Average Cost Per Enlistment (CY'75 $)	Marginal Cost per Enlistment (CY'75 $)
CY 1975 Actual	22,200	$ 48.0	$ 2,160	$ 3,375
CY 1978	+ 400	46.5	2,100	3,050
CY 1982	+ 0	48.0	2,160	3,375
CY 1986	(1,650)	53.0	2,390	4,100

For the Marine Corps, the results show that essentially a 10 percent increase in the accession budget would be sufficient to offset projected declines in enlistments experienced by CY 1986. While its accession budget need be increased by only 10 percent, its marginal cost will be 20 percent higher than CY 1975 levels and it does suggest that alternatives which may be more cost-effective should be evaluated to compensate for the lost enlistments anticipated by 1986.

The Air Force is anticipated to experience declines in quality enlistments due to both population and unemployment shifts by CY 1986. In spite of the fact that the Air Force is projected to experience a 13 percent decline in enlistments, only minimal increases in its accession budget will be required to compensate for this shift in quality enlistment supply. The results of this analysis are shown on Table 6.7.

Table 6.7

CHANGE IN ACCESSION BUDGET TO OVERCOME PROJECTED DECLINE IN NPS MALE DHSG I-IIIA FROM CY 1975 LEVEL

AIR FORCE

	Shortfall from CY'75 Level	Accession Budget Required to Maintain CY'75 Levels (Millions CY'75 $	Average Cost Per Enlistment (CY'75 $)	Marginal Cost per Enlistment (CY'75 $)
CY 1975 Actual	44,200	$ 54.0	$ 1,220	$ 1,075
CY 1978	(900)	55.0	1,240	1,100
CY 1982	(3,200)	56.5	1,280	1,150
CY 1986	(5,600)	58.0	1,310	1,175

At the margin, Air Force recruiters are approximately four times more productive than Army recruiters for the same quality group. As a consequence, an increase in their accession budget of about 7 percent would be sufficient to sustain CY 1975 quality enlistment levels for the Air Force. At that level, only minimal increases in marginal costs will occur.

In summary, it is evident from the analyses that only the Army faces a severe budget problem if it attempts to compensate for the shifts in enlistment supply through additions to its accession budget. Serious examination of more cost-effective management options which results in a broadening of the enlistable market in contrast to the costly approach of increasing penetration of the currently defined enlistable market, i.e., male, DHSG, I-IIIA applicants, is essential at the present time.

APPENDIX A

LINEARIZATION TRANSFORMATIONS FOR LEAST SQUARES PROBLEMS

LINEARIZATION TRANSFORMATIONS FOR LEAST SQUARES PROBLEMS

W. G. DOTSON, JR., North Carolina State University

In various elementary courses of mathematics and statistics, the student is introduced to least squares curve fitting. After learning to obtain linear least squares fits, he is almost invariably presented with the form $y=ae^{bx}$ and told that by application of the transformation $z=\ln y$ he can reduce the least squares problem associated with this exponential form to a linear least squares problem. What he is seldom told, however, is that the application of the logarithmic transformation distorts his scale so that minimization of $\sum(\ln y_i-(\ln a+bx_i))^2$ is not equivalent to minimization of $\sum(y_i-ae^{bx_i})^2$. This observation is not new, see [1], p. 195, for example, but it has been neglected to the extent that the student is seldom given a valid method for application of linearization transformations. Some authors (see [4], p. 709, and, [5], pp. 186–191, for example) point out the errors that can result from nonrigorous linearization, but then, rather than proposing a valid method for linearization, they suggest the iterative method of differential corrections as an alternative to be preferred. Many others choose to propose nonrigorous linearization exercises with no word of caution for the student. The few authors who do point the way to a valid linearization method generally seem to base their discussions on the idea of statistical weighting, and they do not appear to attempt a rigorous mathematical justification of the method or a computation of error bounds (for example, see [1], p. 194; [2], p. 302; [3], p. 536). All of this is unfortunate, since many least squares problems arising in data analysis are associated with simple nonlinear forms which are susceptible to linearization transformations. A few such forms and the associated transformations are listed below.

Form	*Linearization Transformation*
$y=ae^{bx}$	$z=\ln y$
$y=ax^b$	$z=\ln y$
$y=\ln(a+bx)$	$z=e^y$
$y=\{a^2+b^2x^2\}^{1/2}$	$z=y^2$
$y=a(x-b)^2$	$z=\sqrt{y}$
$y=a/(b-x)$	$z=1/y$
$y=ax/(b-x)$	$z=1/y$

For forms such as these, the use of linearization transformations is both computationally more efficient and aesthetically more satisfying than the use of iterative techniques, such as the method of differential corrections and the Newton-Raphson method, to solve the nonlinear normal equations. Of course, the accuracy obtainable with linearization transformations is not as good as that obtainable with the iterative techniques; but, even when very high accuracy is required, linearization transformations are of value in providing good initial estimates for the iterative techniques. The purpose of this note, then, is to establish, for the undergraduate, a theoretical framework within which the proper application of linearization transformations can be justified.

For conciseness, we will consider forms $y=f(x, a, b)$ which involve only two parameters to be determined by least squares. The results are perfectly general, however, and their extension to any number of parameters is obvious. Suppose, then, that we are given the form $y=f(x, a, b)$ and a set of data points $\{(x_i, y_i)\}_{i=1}^{n}$, $n>2$. We consider the least squares problem of minimizing the function

$$S(a, b) = \sum_{i=1}^{n} \{y_i - f(x_i, a, b)\}^2.$$

It is assumed that there is a set $X \subset R_1$, with $x_i \in X$ $(i=1, \cdots, n)$, and an open set $D \subset R_2$ such that f is a function from $X \times D$ to R_1 and S is a function from D to R_1 (where R_k denotes the set of all k-tuples of real numbers, with the Euclidean metric topology). For each i $(i=1, \cdots, n)$, the partial derivatives of $f(x_i, a, b)$ with respect to a and b are assumed to exist at all points of D. Let Y

be a connected subset of R_1 which contains the range of f and the numbers $y_1, \cdots, y_n$ from the data. A function $g: Y \rightarrow R_1$ is said to be a *linearization transformation* for the form $y=f(x, a, b)$ provided there exist functions P, Q, R, from X to R_1, and functions A, B, from D to R_1, such that for all $x \in X$ and all $(a, b) \in D$

$$g[f(x, a, b)] = A(a, b)P(x) + B(a, b)Q(x) + R(x)$$

and such that the Jacobian $\partial(A, B)/\partial(a, b)$ is nonvanishing in D. For example, consider the form $y=a(x-b)^2$, and let $m=$smallest x_i in the set of data. Let $X=\{x: x \geqq m\}$ and let $D=\{a: a>0\} \times \{b: b<m\}$. Let $f(x, a, b)=a(x-b)^2$ for all $x \in X$ and all $(a, b) \in D$. Suppose all the y_i's are positive, and let $Y=\{y: y>0\}$. Then $g(y)=y^{1/2}$ is a linearization transformation for the form $y=f(x, a, b) = a(x-b)^2$, since $g[a(x-b)^2]=Ax+B$ where $A=A(a, b)=\sqrt{a}$ and $B=B(a, b) = -b\sqrt{a}$ for all (a, b) in D, and $\partial(A, B)/\partial(a, b)=-1/2$. Here, of course, P leaves all points of X fixed, Q maps all points of X to 1, and R maps all points of X to 0.

We return now to the general case. If g is a linearization transformation for the form $y=f(x, a, b)$ then, for any given set of numbers $w_1, \cdots, w_n$, one can consider the least squares problem of determining a and b so that the function

$$\begin{aligned} T(a, b; w_1, \cdots, w_n) &= \sum_{i=1}^{n} w_i\{g[y_i] - g[f(x_i, a, b)]\}^2 \\ &= \sum_{i=1}^{n} w_i\{g[y_i] - [A(a, b)P(x_i) + B(a, b)Q(x_i) + R(x_i)]\}^2 \\ &= H(A, B; w_1, \cdots, w_n) \end{aligned}$$

will be minimized. For each set of numbers $w_1, \cdots, w_n$, this associated least squares problem is a *weighted linear least squares problem* in terms of the parameters A and B, so that the normal equations $\partial H/\partial A = \partial H/\partial B = 0$ are linear and can be solved for A and B by the usual methods for linear systems. One can then obtain a and b by simultaneous solution of the equations $A(a, b)=A$, $B(a, b)=B$, since $\partial(A, B)/\partial(a, b) \neq 0$.

THEOREM. *Suppose $S(a, b)$ is minimized at the point (a_0, b_0) in D. If the linearization transformation g has a nonzero derivative at each point of Y, then there exist numbers $w_1, \cdots, w_n$ such that $T(a, b; w_1, \cdots, w_n)$ is minimized at (a_0, b_0).*

Proof. We have $\partial S/\partial a = \partial S/\partial b = 0$ at (a_0, b_0), whence

$$\sum_{i=1}^{n} (y_i - f(x_i, a_0, b_0))f_a(x_i, a_0, b_0) = 0$$

$$\sum_{i=1}^{n} (y_i - f(x_i, a_0, b_0))f_b(x_i, a_0, b_0) = 0.$$

For any numbers $w_1, \cdots, w_n$ we have

$$T_a(a_0, b_0; w_1, \cdots, w_n)$$

$$= -2\sum_{i=1}^{n} w_i\{g[y_i] - g[f(x_i, a_0, b_0)]\}g'[f(x_i, a_0, b_0)]\cdot f_a(x_i, a_0, b_0).$$

By the mean value theorem, for each i $(i=1, \cdots, n)$ there exists a point ξ_i between y_i and $f(x_i, a_0, b_0)$ such that

$$g[y_i] - g[f(x_i, a_0, b_0)] = g'(\xi_i)\{y_i - f(x_i, a_0, b_0)\}$$

and so we see that we will have $T_a(a_0, b_0; w_1, \cdots, w_n)=0$ provided we set $w_i=1/\{g'(\xi_i)g'[f(x_i, a_0, b_0)]\}$, $i=1, \cdots, n$. It is clear that this same set of w_i's will make $T_b(a_0, b_0; w_1, \cdots, w_n)=0$. Now since

$$\frac{\partial T}{\partial a} = \frac{\partial H}{\partial A}\cdot\frac{\partial A}{\partial a} + \frac{\partial H}{\partial B}\cdot\frac{\partial B}{\partial a}, \qquad \frac{\partial T}{\partial b} = \frac{\partial H}{\partial A}\cdot\frac{\partial A}{\partial b} + \frac{\partial H}{\partial B}\cdot\frac{\partial B}{\partial b},$$

and since the Jacobian $\partial(A, B)/\partial(a, b)\neq 0$ at (a_0, b_0), we see that $\partial H/\partial A = \partial H/\partial B = 0$ at $A_0=A(a_0, b_0)$, $B_0=B(a_0, b_0)$. But it is well known that the linear normal equations $\partial H/\partial A = \partial H/\partial B = 0$ have a unique solution and that this solution does indeed correspond to the minimum of the function $H(A, B; w_1, \cdots, w_n) = T(a, b; w_1, \cdots, w_n)$.

From a practical standpoint, one must, of course, use estimates of these weights $w_i=1/\{g'(\xi_i)g'[f(x_i, a_0, b_0)]\}$ in the linearization procedure. Since it is expected that a_0 and b_0 will turn out such that $f(x_i, a_0, b_0)$ will be fairly close to y_i, for $i=1, \cdots, n$, and since ξ_i must be between $f(x_i, a_0, b_0)$ and y_i, it is reasonable to use $w_i^*=1/\{g'(y_i)\}^2$ as an estimate of w_i provided g' is continuous. One can then solve the weighted linear least squares problem, using the weights w_i^*, to obtain A_0^*, B_0^*; and a_0^*, b_0^* are then obtained by simultaneous solution of the equations $A(a_0^*, b_0^*)=A_0^*$, $B(a_0^*, b_0^*)=B_0^*$. The remaining problem is to estimate upper bounds for $|\Delta a_0^*| = |a_0^* - a_0|$ and $|\Delta b_0^*| = |b_0^* - b_0|$. We have

$$\Delta w_i^* = w_i^* - w_i = \frac{1}{\{g'(y_i)\}^2} - \frac{1}{g'(\xi_i)g'(f(x_i, a_0, b_0))}.$$

Assuming g' to be monotonic, (which will generally be the case in applications) we have

$$|\Delta w_i^*| \leqq \left|\frac{1}{\{g'(y_i)\}^2} - \frac{1}{\{g'(f(x_i, a_0, b_0))\}^2}\right|.$$

If we assume the existence of g'' at all points of Y (again a plausible assumption), then the mean value theorem gives us the existence of points η_i between y_i and $f(x_i, a_0, b_0)$ such that

$$|\Delta w_i^*| \leqq \left|\frac{-2g''(\eta_i)}{\{g'(\eta_i)\}^3}\{y_i - f(x_i, a_0, b_0)\}\right|.$$

Finally, assuming $|2g''/(g')^3| \leqq M$ on Y (or, at least, on a connected subset of Y containing the points y_i and $f(x_i, a_0, b_0)$ $i=1, \cdots, n$), we have

$$|\Delta w_i^*| \leqq M \cdot |y_i - f(x_i, a_0, b_0)|$$

and so

$$\sum_{i=1}^{n} (\Delta w_i^*)^2 \leqq M^2 \sum_{i=1}^{n} \{y_i - f(x_i, a_0, b_0)\}^2 \leqq M^2 \sum_{i=1}^{n} \{y_i - f(x_i, a_0^*, b_0^*)\}^2$$

since $S(a, b)$ is minimized at (a_0, b_0).

Differentiating the normal equations $\partial H/\partial A = \partial H/\partial B = 0$ partially with respect to w_i^* yields equations which are linear in $\partial A_0^*/\partial w_i^*$ and $\partial B_0^*/\partial w_i^*$. Hence, we get

$$\frac{\partial A_0^*}{\partial w_i^*} = k_i\{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\} \quad \text{and} \quad \frac{\partial B_0^*}{\partial w_i^*} = l_i\{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\},$$

where

$$k_i = \frac{P(x_i) \sum_{j=1}^{n} w_j^* Q(x_j)^2 - Q(x_i) \sum_{j=1}^{n} w_j^* P(x_j)Q(x_j)}{\left(\sum_{j=1}^{n} w_j^* P(x_j)^2\right)\left(\sum_{j=1}^{n} w_j^* Q(x_j)^2\right) - \left(\sum_{j=1}^{n} w_j^* P(x_j)Q(x_j)\right)^2}$$

and

$$l_i = \frac{Q(x_i) \sum_{j=1}^{n} w_j^* P(x_j)^2 - P(x_i) \sum_{j=1}^{n} w_j^* P(x_j)Q(x_j)}{\left(\sum_{j=1}^{n} w_j^* P(x_j)^2\right)\left(\sum_{j=1}^{n} w_j^* Q(x_j)^2\right) - \left(\sum_{j=1}^{n} w_j^* P(x_j)Q(x_j)\right)^2}.$$

Finally, we have

$$\Delta A_0^* \approx \sum_{i=1}^{n} \frac{\partial A_0^*}{\partial w_i^*} \Delta w_i^*$$

so that, using the Cauchy-Schwarz inequality

$$(\Delta A_0^*)^2 \leqq \left\{ \sum_{i=1}^{n} \left(\frac{\partial A_0^*}{\partial w_i^*}\right)^2 \right\} \cdot \left\{ \sum_{i=1}^{n} (\Delta w_i^*)^2 \right\},$$

whence

$$(\Delta A_0^*)^2 \leqq \left(\sum_{i=1}^{n} k_i^2 \{g[y_i] - g[f(x_i, a_0^*, b_0^*)]\}^2 \right) \left(M^2 \sum_{i=1}^{n} \{y_i - f(x_i, a_0^*, b_0^*)\}^2 \right).$$

Similarly, we obtain

$$(\Delta B_0^*)^2 \leqq \left(\sum_{i=1}^{n} l_i^2 \{ g[y_i] - g[f(x_i, a_0^*, b_0^*)] \}^2 \right) \left(M^2 \sum_{i=1}^{n} \{ y_i - f(x_i, a_0^*, b_0^*) \}^2 \right).$$

Bounds for Δa_0^* and Δb_0^* can now be obtained by examining the transformations $A(a, b)$, $B(a, b)$ to see what region of the ab-plane corresponds to the region $A_0^* \pm |\Delta A_0^*|_{\max}$, $B_0^* \pm |\Delta B_0^*|_{\max}$ of the AB-plane.

As a numerical example, consider fitting the three data points $(x_i, y_i) = (3, 0.2), (4, 2.3), (5, 4.4)$, with the form $f(x, a, b) = a(x-b)^2$ discussed above. One may easily check that an exact solution of the normal equations is $a_0 = .500$, $b_0 = 2.00$, and that this solution does indeed minimize $S(a, b)$. Linearization is accomplished by the transformation $g[y] = y^{1/2}$, and we have $A = \sqrt{a}$, $B = -b\sqrt{a}$, $P(x) = x$, $Q(x) = 1$, $R(x) = 0$. Using the weights $w_i^* = 1/\{g'[y_i]\}^2 = 4y_i$ we obtain $A_0^* = .6579$ and $B_0^* = -1.176$, whence $a_0^* = (A_0^*)^2 = .433$ and $b_0^* = -B_0^*/A_0^* = 1.79$. Noting that $-2g''/(g')^3 \equiv 4$, we compute error bounds as indicated above: $|\Delta A_0^*| \leqq .1317$, $|\Delta B_0^*| \leqq 0.631$. Hence A_0 should be in the interval $[.5262, .7896]$, and B_0 should be in the interval $[-1.807, -0.545]$. The actual values of A_0, B_0 are, of course, $A_0 = .7071$ and $B_0 = -1.414$. The inverse transformation equations $a = A^2$, $b = -B/A$ now give us at once the following bounds for a_0 and b_0: $.277 \leqq a_0 \leqq .623$, $0.69 \leqq b_0 \leqq 3.43$. It is interesting to observe that the usual nonrigorous linearization (accomplished with the same transformation but with all weights set equal to 1) yields $A_0^{**} = .8252$, $B_0^{**} = -1.947$, whence $a_0^{**} = (A_0^{**})^2 = .681$ and $b_0^{**} = -B_0^{**}/A_0^{**} = 2.36$. We note that $|a_0^{**} - a_0| > |a_0^* - a_0|$ and $|b_0^{**} - b_0| > |b_0^* - b_0|$, and that the error bounds obtained above for a_0 actually exclude the value $a_0^{**} = .681$. Finally, we have $S(a_0, b_0) = .190$, $S(a_0^*, b_0^*) = .226$, and $S(a_0^{**}, b_0^{**}) = .345$.

It is to be noted that our error bounds for A_0^* and B_0^* are, in fact, bounds for the total differentials of A_0^* and B_0^* with respect to the w_i^*, $i = 1, \cdots, n$. These bounds are therefore approximate. We recall, however, that $|\Delta w_i^*| \leqq M \cdot |y_i - f(x_i, a_0, b_0)|$ so that if a good fit of the data is possible with the form $y = f(x, a, b)$ and if $|2g''/(g')^3|$ is not too large, then the Δw_i^* will be small and our error bounds should be valid. In practice, an indication of the validity of the bounds can be obtained by observing the size of $M^2 \sum_{i=1}^{n} \{y_i - f(x_i, a_0^*, b_0^*)\}^2$ which is an upper bound for $\sum_{i=1}^{n} (\Delta w_i^*)^2$.

References

1. W. E. Deming, Statistical Adjustment of Data, Wiley, New York, 1943.
2. K. L. Nielsen, Methods in Numerical Analysis, 2nd. ed., Macmillan, New York, 1964.
3. J. B. Scarborough, Numerical Mathematical Analysis, 5th ed., Johns Hopkins Press, Baltimore, 1962.
4. I. S. Sokolnikoff, and R. M. Redheffer, Mathematics of Physics and Modern Engineering, McGraw-Hill, New York, 1953.
5. C. R. Wylie, Jr., Advanced Engineering Mathematics, 2nd. ed., McGraw-Hill, New York, 1960.

APPENDIX B

SOURCE DATA

Table B-1

GRC VOLUNTEER DATA BASE EXTRACT   SERVICE = ARMY
DATA COVERS JAN-DEC 76   SERVICE CODE = 1
(NPS MALE ACCESSIONS , H.S. GRADS)

SEQ. NO.	STATE	WHITE CAT 1,2	WHITE CAT 3A	WHITE CAT 3B	WHITE CAT 4	BLACK + OTHER CAT 1,2	BLACK + OTHER CAT 3A	BLACK + OTHER CAT 3B	BLACK + OTHER CAT 4	TOTAL
1	ALABAMA	401	278	181	11	233	461	592	93	2,250
2	ALASKA	34	20	9	5	2	1	3	4	78
4	ARIZONA	511	243	233	51	16	21	68	16	1,159
5	ARKANSAS	230	150	148	39	46	94	264	132	1,103
6	CALIFORNIA	2,796	1,788	1,914	672	225	383	836	496	9,110
8	COLORADO	453	243	219	58	16	20	45	16	1,070
9	CONNECTICUT	432	190	156	50	18	29	78	54	1,007
10	DELAWARE	80	49	44	16	10	14	58	36	307
11	WASHINGTON DC	8	3	4	2	27	44	113	58	259
12	FLORIDA	1,718	906	713	59	105	271	752	193	4,717
13	GEORGIA	706	419	394	37	163	304	882	185	3,090
15	HAWAII	37	24	29	9	69	88	199	104	559
16	IDAHO	208	84	71	19	1	2	4	2	391
17	ILLINOIS	1,303	650	594	174	97	192	507	274	3,791
18	INDIANA	1,019	534	484	125	53	55	141	91	2,502
19	IOWA	579	246	202	63	5	6	16	7	1,124
20	KANSAS	341	139	143	29	9	18	37	22	738
21	KENTUCKY	353	281	360	66	28	51	139	52	1,330
22	LOUISIANA	141	97	90	10	91	189	513	260	1,391
23	MAINE	255	171	161	30	1	0	1	0	619
24	MARYLAND	441	271	250	59	58	114	312	188	1,693
25	MASSACHUSETTS	917	465	395	81	18	32	61	39	2,008
26	MICHIGAN	1,321	773	814	223	71	132	322	154	3,810
27	MINNESOTA	928	459	333	88	6	6	13	1	1,834
28	MISSISSIPPI	142	88	85	22	73	153	403	261	1,227
29	MISSOURI	739	385	370	79	32	53	125	87	1,870
30	MONTANA	231	95	59	21	5	4	8	3	426
31	NEBRASKA	291	129	110	33	9	8	15	14	609
32	NEVADA	102	44	37	11	4	7	15	12	232
33	NEW HAMPSHIRE	278	119	99	16	0	0	0	0	512
34	NEW JERSEY	840	396	353	75	106	174	346	127	2,417
35	NEW MEXICO	179	129	206	41	7	11	35	20	628
36	NEW YORK	2,109	1,090	1,029	226	191	299	662	244	5,850
37	NORTH CAROLINA	735	538	382	43	228	486	905	142	3,459
38	NORTH DAKOTA	120	64	58	13	4	4	5	5	273
39	OHIO	1,783	1,053	1,061	256	83	156	372	205	4,969
40	OKLAHOMA	445	217	233	79	27	42	136	85	1,264
41	OREGON	573	252	219	65	5	7	15	3	1,139
42	PENNSYLVANIA	1,892	892	797	200	94	214	421	217	4,727
44	RHODE ISLAND	171	74	36	19	6	4	13	5	328
45	SOUTH CAROLINA	237	168	155	4	113	255	560	88	1,580
46	SOUTH DAKOTA	194	86	70	17	6	5	11	4	393
47	TENNESSEE	491	325	318	62	47	136	351	202	1,932
48	TEXAS	1,307	773	900	279	170	293	640	384	4,746
49	UTAH	222	104	91	31	2	1	8	4	463
50	VERMONT	132	64	68	16	0	0	0	0	280
51	VIRGINIA	645	283	237	32	275	356	572	144	2,544
53	WASHINGTON	814	359	299	93	19	17	26	26	1,653
54	WEST VIRGINIA	189	165	220	49	10	11	38	14	697
55	WISCONSIN	926	404	327	76	14	23	35	30	1,835
56	WYOMING	44	26	19	4	1	1	2	1	98
	TOTALS	31,043	16,805	15,779	3,838	2,899	5,247	11,675	4,805	92,091

DATA COVERS JAN-DEC 75

GRC VOLUNTEER DATA BASE EXTRACT

SERVICE = NAVY
SERVICE CODE = 2

(NPS MALE ACCESSIONS , H.S. GRADS)

SEQ. NO.	STATE	WHITE CAT 1,2	WHITE CAT 3A	WHITE CAT 3B	WHITE CAT 4	BLACK+OTHER CAT 1,2	BLACK+OTHER CAT 3A	BLACK+OTHER CAT 3B	BLACK+OTHER CAT 4	TOTAL
1	ALABAMA	408	310	180	4	57	143	84	6	1,192
2	ALASKA	39	17	4	4	0	2	0	0	66
4	ARIZONA	494	245	122	12	26	13	6	3	922
5	ARKANSAS	281	193	108	24	20	55	50	18	749
6	CALIFORNIA	3,422	1,918	1,262	279	174	300	379	122	7,856
8	COLORADO	558	311	170	56	20	19	17	3	1,153
9	CONNECTICUT	426	229	149	43	19	19	14	9	908
10	DELAWARE	80	40	36	8	3	2	6	9	184
11	WASHINGTON DC	8	2	0	1	13	18	26	12	80
12	FLORIDA	1,277	764	309	13	53	69	87	3	2,575
13	GEORGIA	536	425	225	37	46	94	92	33	1,488
15	HAWAII	40	25	21	7	30	24	33	16	196
16	IDAHO	196	106	39	10	6	2	1	0	360
17	ILLINOIS	1,130	684	446	152	85	128	156	100	2,941
18	INDIANA	741	487	308	91	57	57	61	26	1,828
19	IOWA	553	261	165	42	25	8	8	3	1,065
20	KANSAS	334	180	103	32	13	7	18	3	690
21	KENTUCKY	313	223	189	67	14	27	38	11	882
22	LOUISIANA	267	239	129	28	32	68	128	61	952
23	MAINE	234	143	79	32	2	4	4	0	498
24	MARYLAND	483	241	151	34	45	46	79	43	1,122
25	MASSACHUSETTS	761	555	317	98	33	31	20	2	1,817
26	MICHIGAN	1,529	935	691	170	52	63	80	19	3,539
27	MINNESOTA	852	393	223	69	32	15	9	9	1,602
28	MISSISSIPPI	160	89	68	10	13	27	29	8	404
29	MISSOURI	756	397	316	90	35	47	51	37	1,729
30	MONTANA	199	95	42	8	10	3	5	0	362
31	NEBRASKA	273	113	91	28	17	10	7	3	542
32	NEVADA	112	66	27	7	5	4	5	0	226
33	NEW HAMPSHIRE	173	84	48	8	7	2	0	0	322
34	NEW JERSEY	811	574	347	117	52	77	115	60	2,153
35	NEW MEXICO	273	168	116	31	5	15	7	3	618
36	NEW YORK	1,949	1,148	747	224	117	176	184	72	4,617
37	NORTH CAROLINA	597	337	242	54	44	78	132	23	1,497
38	NORTH DAKOTA	139	53	23	6	3	1	0	0	225
39	OHIO	1,697	1,067	675	212	90	146	117	47	4,051
40	OKLAHOMA	424	259	163	32	31	43	31	6	989
41	OREGON	599	310	152	44	24	6	5	1	1,141
42	PENNSYLVANIA	1,714	950	676	217	136	111	175	86	4,035
44	RHODE ISLAND	114	54	38	13	7	10	5	2	243
45	SOUTH CAROLINA	271	151	99	29	25	47	74	32	728
46	SOUTH DAKOTA	133	68	36	8	3	6	4	0	258
47	TENNESSEE	470	284	176	33	35	72	75	11	1,156
48	TEXAS	1,908	1,197	834	200	135	163	191	62	4,690
49	UTAH	154	97	43	3	4	2	3	0	306
50	VERMONT	79	59	45	14	1	1	0	0	199
51	VIRGINIA	498	247	179	48	34	50	82	38	1,176
53	WASHINGTON	801	446	247	73	49	30	17	5	1,660
54	WEST VIRGINIA	161	108	72	32	10	8	8	8	407
55	WISCONSIN	759	399	226	66	21	26	25	15	1,537
56	WYOMING	98	51	22	1	2	1	1	1	177
	TOTALS	30,334	17,797	11,176	2,921	1,742	2,376	2,744	1,031	70,121

Table B-3

DATA COVERS JAN-DEC 76

GRC VOLUNTEER DATA BASE EXTRACT

SERVICE = AIR FORCE
SERVICE CODE = 4

(NPS MALE ACCESSIONS , H.S. GRADS)

SEQ. NO.	STATE	WHITE CAT 1,2	WHITE CAT 3A	WHITE CAT 3B	WHITE CAT 4	BLACK + OTHER CAT 1,2	BLACK + OTHER CAT 3A	BLACK + OTHER CAT 3B	BLACK + OTHER CAT 4	TOTAL
1	ALABAMA	275	236	208	8	27	62	91	5	912
2	ALASKA	22	9	2	0	0	1	0	0	34
4	ARIZONA	396	222	143	13	11	13	5	1	804
5	ARKANSAS	228	156	133	5	6	41	31	2	602
6	CALIFORNIA	2,266	1,491	993	33	203	237	202	7	5,432
8	COLORADO	424	213	110	7	8	17	13	0	792
9	CONNECTICUT	365	213	115	15	16	16	22	2	764
10	DELAWARE	74	39	39	0	8	11	11	1	183
11	WASHINGTON DC	3	1	1	0	25	31	29	0	90
12	FLORIDA	1,281	826	500	19	58	112	136	10	2,942
13	GEORGIA	407	331	210	4	64	122	138	8	1,284
15	HAWAII	39	23	13	1	95	67	52	0	290
16	IDAHO	163	82	46	2	0	0	0	0	293
17	ILLINOIS	802	476	301	9	87	126	90	3	1,894
18	INDIANA	732	455	315	9	25	33	41	1	1,612
19	IOWA	364	208	110	11	3	6	5	1	708
20	KANSAS	228	142	74	12	8	16	13	2	495
21	KENTUCKY	338	261	186	4	16	33	38	0	876
22	LOUISIANA	271	172	136	12	62	131	152	7	943
23	MAINE	287	188	159	2	1	1	0	0	638
24	MARYLAND	357	204	144	4	71	76	108	0	964
25	MASSACHUSETTS	814	561	378	23	21	32	35	1	1,865
26	MICHIGAN	1,206	758	433	14	60	97	93	3	2,664
27	MINNESOTA	561	314	180	8	3	4	1	0	1,071
28	MISSISSIPPI	178	109	87	4	21	48	90	1	538
29	MISSOURI	647	425	252	17	52	62	58	0	1,513
30	MONTANA	146	55	37	1	2	0	1	0	242
31	NEBRASKA	178	95	52	2	7	6	8	0	348
32	NEVADA	66	42	27	0	1	1	4	0	141
33	NEW HAMPSHIRE	195	130	84	3	0	0	0	0	412
34	NEW JERSEY	565	343	248	8	61	93	88	0	1,406
35	NEW MEXICO	151	103	68	3	5	7	5	0	342
36	NEW YORK	1,696	953	592	29	158	227	184	2	3,841
37	NORTH CAROLINA	408	325	234	18	69	144	153	12	1,363
38	NORTH DAKOTA	47	38	17	1	1	2	1	0	107
39	OHIO	1,777	988	658	22	113	178	151	6	3,893
40	OKLAHOMA	332	222	154	16	23	40	35	3	825
41	OREGON	382	204	119	4	4	3	2	0	718
42	PENNSYLVANIA	1,529	820	524	16	64	91	114	1	3,159
44	RHODE ISLAND	143	92	41	3	2	2	2	0	285
45	SOUTH CAROLINA	187	160	121	6	29	91	116	4	714
46	SOUTH DAKOTA	114	69	46	2	2	3	0	0	236
47	TENNESSEE	393	296	218	13	42	78	87	1	1,128
48	TEXAS	1,323	957	595	43	80	169	201	6	3,374
49	UTAH	131	74	49	2	2	1	0	0	259
50	VERMONT	122	68	47	1	0	0	1	0	239
51	VIRGINIA	475	283	152	16	31	112	93	5	1,187
53	WASHINGTON	585	323	193	9	13	14	7	0	1,144
54	WEST VIRGINIA	239	190	137	4	11	12	12	0	605
55	WISCONSIN	589	341	175	5	12	11	9	0	1,142
56	WYOMING	27	16	7	0	1	1	0	0	52
	TOTALS	24,528	15,303	9,863	463	1,794	2,681	2,728	95	57,365

Table B-4

DATA COVERS JAN-DEC 75

GRD VOLUNTEER DATA BASE EXTRACT

SERVICE = MARINES
SERVICE CODE = 3

(NPS MALE ACCESSIONS , H.S. GRADS)

		WHITE				BLACK + OTHER				
SEQ. NO.	STATE	CAT 1,2	CAT 3A	CAT 3B	CAT 4	CAT 1,2	CAT 3A	CAT 3B	CAT 4	TOTAL
1	ALABAMA	77	75	83	6	40	70	104	12	468
2	ALASKA	11	3	7	2	0	0	1	0	24
4	ARIZONA	154	85	53	8	15	15	18	1	349
5	ARKANSAS	94	51	60	5	28	28	35	7	308
6	CALIFORNIA	1,081	743	607	51	118	134	141	22	2,903
8	COLORADO	244	123	93	8	3	2	4	2	479
9	CONNECTICUT	188	105	81	5	32	18	16	1	446
10	DELAWARE	31	21	9	1	8	8	12	2	92
11	WASHINGTON DC	0	0	0	1	14	23	28	5	71
12	FLORIDA	325	265	178	12	17	46	98	9	951
13	GEORGIA	135	117	100	7	43	58	96	5	561
15	HAWAII	6	5	4	0	23	27	38	3	106
16	IDAHO	62	29	36	2	0	0	1	0	129
17	ILLINOIS	655	389	266	34	83	130	205	36	1,798
18	INDIANA	350	315	274	34	16	36	67	13	1,105
19	IOWA	214	111	81	7	1	3	1	0	418
20	KANSAS	197	82	88	11	13	12	9	2	414
21	KENTUCKY	128	92	86	11	22	14	10	1	364
22	LOUISIANA	136	87	55	4	72	102	100	12	568
23	MAINE	69	42	45	4	1	0	0	0	161
24	MARYLAND	207	150	107	5	45	69	58	8	649
25	MASSACHUSETTS	373	260	214	23	8	20	21	2	921
26	MICHIGAN	612	411	352	43	47	74	101	22	1,662
27	MINNESOTA	337	194	114	12	3	7	5	0	672
28	MISSISSIPPI	55	29	47	3	8	27	50	8	227
29	MISSOURI	343	243	189	28	43	55	50	7	958
30	MONTANA	53	34	19	4	3	1	1	0	115
31	NEBRASKA	121	70	53	4	6	8	6	2	270
32	NEVADA	32	28	15	2	0	1	0	0	78
33	NEW HAMPSHIRE	84	44	44	0	0	0	0	0	172
34	NEW JERSEY	338	190	162	16	71	77	82	14	950
35	NEW MEXICO	85	73	85	8	4	6	11	1	279
36	NEW YORK	847	481	389	31	183	164	197	22	2,314
37	NORTH CAROLINA	130	104	79	14	65	100	129	16	637
38	NORTH DAKOTA	42	32	18	3	3	2	3	0	103
39	OHIO	664	404	327	42	72	109	101	15	1,734
40	OKLAHOMA	142	72	40	7	21	19	24	2	327
41	OREGON	164	93	80	6	0	0	0	0	343
42	PENNSYLVANIA	659	395	325	38	78	87	100	11	1,693
44	RHODE ISLAND	57	33	30	0	3	2	3	0	128
45	SOUTH CAROLINA	53	52	37	3	16	32	75	9	277
46	SOUTH DAKOTA	46	39	23	2	1	2	4	0	116
47	TENNESSEE	97	83	51	3	33	56	50	4	377
48	TEXAS	717	432	323	31	95	83	80	11	1,772
49	UTAH	38	13	9	4	0	1	0	0	71
50	VERMONT	21	18	20	0	0	0	0	0	59
51	VIRGINIA	218	153	126	15	36	71	104	17	740
53	WASHINGTON	247	173	113	16	7	3	6	4	569
54	WEST VIRGINIA	76	87	78	4	6	3	11	1	266
55	WISCONSIN	471	294	163	13	9	12	8	1	971
56	WYOMING	18	14	9	2	1	1	1	0	46
	TOTALS	11,504	7,456	5,847	595	1,416	1,818	2,265	310	31,211

Table B-5

TOTAL HIGH SCHOOL GRADUATE QMA POPULATION AS OF JUNE, 1977

	WHITES BY MENTAL CATAGORY						NON-WHITES BY MENTAL CATAGORY					
STATE	I	II	IIIA	I-IIIA	IIIB	I-III	I	II	IIIA	I-IIIA	IIIB	I-III
AL	970	8275	5558	14803	6016	20819	2	195	436	633	1065	1698
AK	16	59	25	100	20	120	0	145	97	242	320	562
AZ	1844	8756	4363	14963	3403	18366	51	312	339	702	609	1311
AR	969	5916	3369	10254	3563	13817	10	210	283	503	869	1372
CA	16981	85580	42256	144817	36848	181665	658	5194	4245	10097	7055	17152
CO	2711	13942	5747	22400	4423	26823	4	155	183	342	246	588
CT	2863	14456	6943	24262	6962	31224	7	151	188	346	654	1000
DE	545	2777	1476	4798	1591	6389	0	81	130	211	424	635
DC	20	99	52	171	43	214	15	229	454	698	1589	2287
FL	3610	26574	14730	44914	16384	61298	11	427	898	1336	5013	6349
GA	1771	13287	8470	23528	8566	32094	6	333	652	991	1972	2963
HI	103	537	216	856	249	1105	448	2352	1275	4075	1168	5243
ID	1262	5197	2390	8849	2256	11105	19	77	57	153	17	170
IL	9613	56956	28712	95481	27354	122835	103	1365	2079	3547	5047	8594
IN	5567	30796	14703	51066	13038	64104	8	316	521	845	1104	1949
IA	5252	25391	10347	40990	7539	48529	1	102	97	200	214	414
KS	3274	16127	6798	26199	5257	31456	44	347	241	632	728	1360
KY	1456	9704	6024	17184	6489	23673	0	66	95	161	213	374
LA	844	7276	4550	12670	5470	18140	13	241	399	653	1428	2081
ME	1093	5147	3112	9352	3052	12404	0	1	51	52	101	153
MD	2786	14612	7495	24893	7781	32674	51	801	965	1817	3369	5186
MA	4608	27590	15463	47661	14853	62514	20	302	329	651	824	1475
MI	7322	48934	25812	82068	26921	108989	29	671	1219	1919	3546	5465
MN	7258	32401	14045	53704	12991	66695	15	136	123	274	178	452
MS	643	4915	2915	8473	3492	11965	2	161	297	460	1215	1675
MO	3664	21751	11134	36549	12887	49436	16	443	791	1250	3077	4327
MT	1370	5559	2245	9174	1820	10994	2	61	79	142	127	269
NB	2513	13005	5723	21241	4881	26122	10	101	131	242	397	639
NV	402	2294	1021	3717	808	4525	8	13	28	49	116	165
NH	816	3828	1903	6547	1645	8192	0	3	6	9	16	25
NJ	4036	27167	15175	46378	13885	60263	23	872	1192	2087	2954	5041
NM	929	4409	2341	7679	2459	10138	11	85	86	182	169	351
NY	11087	62447	34243	107777	32580	140357	117	1769	2672	4558	6244	10602
NC	1784	13695	8601	24280	8989	33269	8	419	791	1218	1798	3016
ND	865	4463	1888	7216	1591	8807	0	26	29	55	104	159
OH	10910	57290	27610	95810	23810	119620	51	1008	1576	2635	2421	5056
OK	2015	10892	5366	18273	4685	22958	21	333	353	707	654	1361
OR	3501	16509	7576	27586	5840	33426	83	529	366	978	366	1344
PA	10094	61560	32432	104086	32173	136259	25	1090	1807	2922	5357	8279
RI	574	4182	2518	7274	2154	9428	0	48	9	57	39	96
SC	556	4972	3223	8751	3265	12016	4	105	255	364	713	1077
SD	948	4782	2174	7904	1461	9365	0	36	46	82	67	149
TN	1749	11670	7716	21135	8496	29631	2	454	520	976	1469	2445
TX	6591	37924	19896	64411	20329	84740	49	637	933	1619	2783	4402
UT	2007	8032	3118	13157	3220	16377	3	34	32	69	74	143
VT	683	3178	1419	5280	1326	6606	0	3	3	6	11	17
VA	2397	15456	8504	26357	10257	36614	10	321	528	859	2123	2982
WA	5025	20163	8744	33932	6451	40383	46	300	241	587	344	931
WV	1033	6319	3998	11350	4630	15980	2	95	99	196	327	523
WI	6899	34530	16338	57767	13467	71234	5	169	177	351	424	775
WY	646	2636	1138	4620	977	5597	16	29	73	118	192	310

abl -6

HIGH SCHOOL GRADUATE QMA POPULATION IN SCHOOL AS OF JUNE, 1977

STATE	WHITES BY MENTAL CATAGORY						NON-WHITES BY MENTAL CATAGORY					
	I	II	IIIA	I-IIIA	IIIB	I-III	I	II	IIIA	I-IIIA	IIIB	I-III
AL	519	4415	2965	7899	3202	11101	1	79	174	254	405	659
AK	6	21	9	36	7	43	0	26	17	43	57	100
AZ	1103	5233	2607	8943	2034	10977	24	144	155	323	285	608
AR	526	3202	1816	5544	1914	7458	9	122	133	264	367	631
CA	9975	50292	24811	85078	21635	106713	484	3468	2487	6439	3569	10028
CO	1565	8068	3327	12960	2552	15512	1	87	102	190	139	329
CT	1808	9127	4383	15318	4396	19714	2	75	78	155	255	410
DE	298	1516	807	2621	870	3491	0	26	43	69	140	209
DC	17	84	44	145	37	182	7	90	175	272	607	879
FL	2104	15481	8576	26161	9542	35703	4	178	372	554	2083	2637
GA	1095	8192	5223	14510	5280	19790	6	111	189	306	573	879
HI	52	270	109	431	126	557	250	1312	712	2274	653	2927
ID	755	3103	1423	5281	1335	6616	16	61	47	124	14	138
IL	5818	33725	16989	56532	16239	72771	64	656	922	1642	2225	3867
IN	3220	17763	8456	29439	7474	36913	5	125	206	336	428	764
IA	3140	15157	6162	24459	4470	28929	0	71	62	133	139	272
KS	2132	10502	4419	17053	3402	20455	33	267	179	479	545	1024
KY	714	4793	3003	8510	3243	11753	0	24	31	55	68	123
LA	449	3867	2419	6735	2906	9641	8	125	164	317	633	950
ME	708	3340	2020	6068	1983	8051	0	1	51	52	101	153
MD	1555	8131	4165	13851	4318	18169	41	477	414	932	1326	2258
MA	2905	17370	9732	30007	9366	39373	13	155	172	340	389	729
MI	4101	27295	14359	45755	14992	60747	16	260	442	718	1236	1954
MN	4073	16229	7900	30202	7290	37492	6	58	51	115	76	191
MS	397	3036	1799	5232	2157	7389	2	112	166	280	635	915
MO	2109	12526	6411	21046	7425	28471	5	177	315	497	1226	1723
MT	871	3530	1427	5828	1159	6987	2	47	61	110	87	197
NB	1500	7785	3432	12717	2935	15652	4	60	90	154	241	395
NV	207	1170	519	1896	415	2311	1	2	4	7	19	26
NH	485	2284	1133	3902	990	4892	0	2	5	7	13	20
NJ	2395	16102	8994	27491	8229	35720	11	366	473	850	1136	1986
NM	539	2566	1365	4470	1436	5906	7	35	44	86	76	162
NY	7022	39109	21281	67412	20135	87547	46	794	970	1810	2135	3945
NC	1031	8020	4967	14018	5191	19209	3	123	239	365	545	910
ND	580	2969	1257	4806	1067	5873	0	2	2	4	6	10
OH	5906	31001	14939	51846	12880	64726	29	386	577	992	913	1905
OK	1266	6828	3363	11457	2932	14389	11	168	171	350	305	655
OR	2062	9743	4473	16278	3448	19726	63	390	251	704	224	928
PA	5662	34685	18325	58672	18251	76923	8	365	587	960	1566	2526
RI	379	2776	1674	4829	1430	6259	0	29	5	34	21	55
SC	346	3117	2026	5489	2051	7540	4	42	81	127	218	345
SD	574	2891	1316	4781	886	5667	0	6	0	6	6	12
TN	989	6581	4353	11923	4792	16715	0	200	206	406	569	995
TX	4064	23315	12207	39586	12477	52063	34	305	390	729	1139	1868
UT	1238	4932	1912	8082	1981	10063	3	16	17	38	41	79
VT	463	2160	964	3587	901	4488	0	2	2	4	9	13
VA	1442	9304	5126	15872	6189	22061	6	109	178	293	725	1018
WA	2970	11899	5156	20025	3808	23833	32	204	164	400	238	638
WV	569	3472	2201	6242	2553	8795	1	64	61	126	196	322
WI	3760	18811	8896	31467	7334	38801	3	72	69	144	154	298
WY	384	1693	678	2755	582	3337	11	20	52	83	132	215

Table B-7

HIGH SCHOOL GRADUATE QMA POPULATION NOT IN SCHOOL AS OF JUNE, 1977

	WHITES BY MENTAL CATAGORY						NON-WHITES BY MENTAL CATAGORY					
STATE	I	II	IIIA	I-IIIA	IIIB	I-III	I	II	IIIA	I-IIIA	IIIB	I-III
AL	451	3860	2593	6904	2814	9718	1	116	262	379	660	1039
AK	10	38	16	64	13	77	0	119	80	199	263	462
AZ	741	3523	1756	6020	1369	7389	27	168	184	379	324	703
AR	443	2714	1553	4710	1649	6359	1	88	150	239	502	741
CA	7006	35288	17445	59739	15213	74952	174	1726	1758	3658	3466	7124
CO	1146	5874	2420	9440	1871	11311	3	68	81	152	107	259
CT	1055	5329	2560	8944	2566	11510	5	76	110	191	399	590
DE	247	1261	669	2177	721	2898	0	55	87	142	284	426
DC	3	15	8	26	6	32	8	139	279	426	962	1408
FL	1506	11093	6154	18753	6842	25595	7	249	526	782	2930	3712
GA	676	5095	3247	9018	3286	12304	0	222	463	685	1359	2064
HI	51	267	107	425	123	548	198	1040	563	1801	515	2316
ID	567	2094	967	3568	921	4489	3	16	10	29	3	32
IL	3995	23231	11723	38949	11115	50064	39	709	1157	1905	2822	4727
IN	2347	13033	6247	21627	5564	27191	3	191	315	509	676	1185
IA	2112	10234	4185	16531	3069	19600	1	31	35	67	75	142
KS	1142	5625	2379	9146	1855	11001	11	80	62	153	183	336
KY	742	4911	3021	8674	3246	11920	0	42	64	106	145	251
LA	395	3409	2131	5935	2564	8499	5	116	215	336	795	1131
ME	385	1607	1092	3284	1069	4353	0	0	0	0	0	0
MD	1231	6481	3330	11042	3463	14505	10	324	551	885	2043	2928
MA	1703	10220	5731	17654	5487	23141	7	147	157	311	435	746
MI	3221	21639	11453	36313	11929	48242	13	411	777	1201	2310	3511
MN	3185	14172	6145	23502	5701	29203	9	78	72	159	102	261
MS	246	1679	1116	3241	1335	4576	0	49	131	180	560	760
MO	1555	9225	4723	15503	5462	20965	11	266	476	753	1851	2604
MT	499	2029	818	3346	661	4007	0	14	18	32	40	72
NB	1013	5220	2291	8524	1946	10470	6	41	41	88	156	244
NV	195	1124	502	1821	393	2214	7	11	24	42	97	139
NH	331	1544	770	2645	655	3300	0	1	1	2	3	5
NJ	1641	11065	6181	18887	5656	24543	12	506	719	1237	1818	3055
NM	390	1843	976	3209	1023	4232	4	50	42	96	93	169
NY	4065	23338	12962	40365	12445	52810	71	975	1702	2748	4109	6857
NC	753	5875	3634	10262	3798	14060	5	296	552	853	1253	2106
ND	285	1494	631	2410	524	2934	0	24	27	51	98	149
OH	5004	26289	12671	43964	10930	54894	22	622	999	1643	1508	3151
OK	749	4064	2003	6816	1753	8569	10	165	182	357	349	706
OR	1439	6766	3103	11308	2392	13700	20	139	115	274	142	416
PA	4432	26875	14107	45414	13922	59336	17	725	1220	1962	3791	5753
RI	195	1406	844	2445	724	3169	0	19	4	23	18	41
SC	210	1855	1197	3262	1214	4476	0	63	174	237	495	732
SD	374	1891	858	3123	575	3698	0	30	46	76	61	137
TN	760	5089	3363	9212	3704	12916	2	254	314	570	880	1450
TX	2527	14609	7689	24825	7852	32677	15	332	543	890	1644	2534
UT	769	3100	1206	5075	1239	6314	0	16	15	31	33	64
VT	220	1018	455	1693	425	2118	0	1	1	2	2	4
VA	955	6152	3378	10485	4068	14553	4	212	350	566	1398	1964
WA	2055	8264	3588	13907	2643	16550	14	96	77	187	106	293
WV	464	2847	1797	5108	2077	7185	1	31	38	70	131	201
WI	3139	15719	7442	26300	6133	32433	2	97	108	207	270	477
WY	262	1143	460	1865	395	2260	5	9	21	35	60	95

Table B -8

Recruiters on Station 31 October 1977

Source: USAREC

State	Army	Navy	USAF	USMC
AL	70	56	24	37
AK	4	2	1	1
AZ	50	33	15	25
AR	42	39	18	20
CA	521	413	141	231
CO	68	60	12	31
CT	64	50	17	31
DE	17	8	6	1
DC	15	5	2	2
FL	142	106	58	50
GA	114	78	33	43
HI	28	10	6	8
ID	22	15	7	2
IL	273	155	67	90
IN	145	84	41	47
IA	80	31	22	33
KS	64	15	11	17
KY	74	43	19	32
LA	68	53	23	29
ME	28	10	10	3
MD	80	66	18	43
MA	133	60	38	37
MI	219	152	53	99
MN	102	80	30	46
MS	41	24	14	5

Table B-8 continued

State	Army	Navy	USAF	USMC
MO	140	100	37	78
MT	16	15	6	2
NE	49	31	9	26
NV	15	10	4	1
NH	23	8	7	19
NJ	137	88	34	43
NM	32	19	9	17
NY	354	235	96	140
NC	111	42	30	44
ND	22	11	4	6
OH	261	168	70	112
OK	70	53	20	27
OR	76	76	17	29
PA	243	118	88	139
RI	24	9	8	2
SC	61	33	15	4
SD	20	5	5	5
TN	92	58	27	36
TX	274	195	84	113
UT	28	14	8	2
VT	18	7	4	0*
VA	106	52	28	38
WA	103	66	27	41
WV	49	20	19	25
WI	117	56	25	48
WY	8	5	2	1

* Replaced by 1 for the regression analysis.

Table B-9

Total Unemployment and Unemployment Rates [1] by State: Annual Averages, 1970–75

State	Unemployment (thousands)						Unemployment rate [2]					
	1975 p	1974	1973	1972	1971	1970	1975 p	1974	1973	1972	1971	1970
Alabama	128.6	78.0	55.7	65.6	60.6	61.9	8.9	5.5	3.9	4.7	5.2	4.7
Alaska	15.8	14.9	13.9	12.9	12.1	9.4	8.6	10.0	10.8	10.5	10.5	8.7
Arizona	90.9	49.2	31.0	32.0	32.8	28.7	10.1	5.0	4.1	4.2	4.7	4.4
Arkansas	70.2	39.9	33.5	30.1	40.1	30.1	8.9	4.8	4.1	4.6	5.4	5.0
California	928.6	698.8	613.0	653.0	730.0	580.0	9.9	7.7	7.0	7.6	8.8	7.2
Colorado	63.3	43.4	36.0	35.2	36.7	40.5	5.5	3.8	3.4	3.6	4.0	4.4
Connecticut	136.4	87.3	77.3	112.0	120.4	76.4	10.1	6.2	5.7	8.2	8.9	5.6
Delaware	23.2	15.1	11.6	11.4	13.3	10.9	9.3	6.0	4.6	4.7	5.7	4.8
District of Columbia [3]	27.1	20.0	58.0	42.7	33.5	37.6	8.1	6.0	4.2	3.8	2.7	3.1
Florida	334.4	208.0	131.0	125.0	135.0	115.0	11.4	6.2	4.3	4.5	4.9	4.4
Georgia	206.0	106.4	81.0	83.0	78.0	76.0	9.6	5.0	3.9	4.1	3.9	4.1
Hawaii	26.8	27.3	23.9	24.7	20.6	14.1	7.4	7.6	7.0	7.3	6.3	4.7
Idaho	27.2	21.1	19.1	19.9	19.4	17.5	7.4	6.0	5.6	6.2	6.3	5.8
Illinois	414.2	223.0	202.0	246.0	241.0	193.0	8.3	4.5	4.1	5.1	5.1	4.1
Indiana	208.6	140.2	98.0	103.0	128.0	111.0	8.8	5.9	4.2	4.5	5.7	5.0
Iowa	77.0	39.2	37.0	45.1	51.4	44.8	5.7	3.0	2.9	3.6	4.2	3.7
Kansas	52.3	36.4	31.5	38.1	51.7	44.6	4.9	3.5	3.1	4.0	5.5	4.8
Kentucky	113.4	64.0	58.6	62.5	69.0	61.4	7.7	4.5	4.4	4.8	5.5	5.0
Louisiana	117.9	97.0	85.7	84.9	93.8	85.9	8.3	6.7	6.0	6.1	7.0	6.6
Maine	44.9	29.3	25.2	29.1	31.3	22.8	10.2	6.7	5.9	7.0	7.6	5.7
Maryland	137.5	66.0	60.0	81.0	70.0	53.4	7.5	3.7	3.5	4.7	4.2	3.3
Massachusetts	343.7	190.0	171.0	160.0	164.0	113.0	12.5	7.2	6.7	6.4	6.6	4.6
Michigan	550.8	335.5	221.0	260.0	277.0	240.8	13.8	8.7	5.8	7.0	7.6	6.7
Minnesota	105.4	77.0	79.0	74.0	73.0	68.0	5.9	4.3	4.4	4.3	4.4	4.2
Mississippi	72.1	37.6	32.9	33.7	39.1	37.6	7.7	4.1	3.6	3.9	4.8	4.8
Missouri	150.6	90.4	73.0	84.0	97.0	63.0	7.3	4.5	3.7	4.2	4.9	3.3
Montana	26.6	21.6	19.6	18.5	17.8	15.3	8.0	6.7	6.3	6.2	6.3	5.5
Nebraska	40.5	26.6	22.7	22.5	23.5	19.4	5.5	3.8	3.3	3.4	3.6	3.1
Nevada	29.0	20.9	15.0	16.9	15.9	12.8	9.7	7.5	6.2	7.0	7.0	5.9
New Hampshire	25.7	13.2	12.7	14.4	14.9	10.2	6.9	3.6	3.9	4.5	4.7	3.3
New Jersey	326.6	225.1	178.0	182.0	172.0	136.0	10.2	6.9	5.6	5.8	5.7	4.6
New Mexico	34.4	26.9	23.5	22.6	23.2	21.0	7.8	6.3	5.7	5.8	6.2	5.9
New York	774.3	470.1	405.2	502.0	495.0	330.0	12.1	6.3	5.4	6.7	6.6	4.5
North Carolina	220.9	111.0	83.0	93.0	106.0	94.0	9.1	4.5	3.5	4.0	4.8	4.3
North Dakota	14.4	13.5	13.3	12.5	13.0	11.0	5.2	3.0	5.1	4.9	5.3	4.6
Ohio	408.3	238.3	197.0	251.0	287.0	235.0	8.5	5.0	4.3	5.5	6.5	5.4
Oklahoma	72.8	50.0	47.1	48.7	51.2	44.5	6.2	4.4	4.2	4.5	4.9	4.4
Oregon	106.9	76.0	52.6	54.4	60.0	54.9	10.2	7.5	5.3	5.7	6.6	6.2
Pennsylvania	457.0	258.3	242.2	265.0	261.1	216.9	8.9	5.1	4.8	5.4	5.4	4.5
Puerto Rico	157.0	116.0	112.0	111.0	94.7	84.0	18.0	13.2	12.0	12.3	11.6	10.8
Rhode Island	65.5	31.3	26.1	27.0	27.2	20.6	14.6	7.3	6.2	6.5	6.8	5.2
South Carolina	131.2	56.0	43.9	49.2	57.4	53.6	11.1	4.5	3.7	4.2	5.3	5.0
South Dakota	13.9	10.6	9.9	10.7	10.2	8.9	4.9	3.5	3.3	3.7	3.7	3.3
Tennessee	157.4	71.8	54.7	62.4	82.3	77.8	8.5	3.9	3.0	3.6	5.0	4.8
Texas	324.9	221.0	193.0	220.0	233.0	202.0	6.1	4.3	3.9	4.5	4.9	4.4
Utah	38.5	29.4	26.8	27.5	27.6	25.5	7.5	5.9	5.7	6.1	6.4	6.1
Vermont	20.7	14.1	11.1	12.7	12.9	9.1	10.0	6.9	5.6	6.5	6.8	4.9
Virginia	149.5	86.0	75.0	73.0	69.0	62.0	6.9	4.0	3.6	3.6	3.6	3.4
Washington	144.3	108.0	112.3	137.0	142.0	129.0	9.3	7.2	7.7	9.5	10.1	9.1
West Virginia	50.6	39.3	37.5	42.5	40.9	37.7	8.2	5.9	5.7	6.5	6.5	6.1
Wisconsin	148.1	98.3	84.0	81.0	84.0	72.0	7.0	4.6	4.1	4.2	4.5	3.9
Wyoming	8.1	5.9	5.5	5.9	6.4	6.1	4.6	3.6	3.5	4.0	4.5	4.5

p Preliminary (11-month) average.

[1] Revised. Data are not comparable with those published in earlier *Manpower Reports*. For explanation see Note on Historic Comparability of Labor Force Statistics at the beginning of the Statistical Appendix. See also *New Procedures for Estimating Unemployment in States and Local Areas*. Report No. 432, Bureau of Labor Statistics, U.S. Department of Labor.

[2] Unemployment as percent of labor force.

[3] Data relate to the entire SMSA.

SOURCE: State employment security agencies cooperating with the U.S. Department of Labor.

Source: Employment and Training Report of the President, transmitted to the Congress, 1976

Table B-10

ESTABLISHMENTS DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P
ALABAMA	$160.34	$174.90	$181.22	39.3	40.3	41.0	$4.08	$4.34	$4.42
Birmingham	193.94	219.37	218.90	39.5	40.4	39.8	4.91	5.43	5.50
Mobile	201.20	210.67	224.47	40.0	39.6	40.3	5.03	5.32	5.57
ALASKA	307.05	335.27	(*)	37.4	41.7	(*)	8.21	8.04	(*)
ARIZONA	186.92	202.58	204.73	38.7	39.8	39.6	4.83	5.09	5.17
Phoenix	187.98	202.29	205.65	38.6	39.9	39.7	4.87	5.07	5.18
Tucson	190.12	209.21	211.72	39.2	39.4	39.5	4.85	5.31	5.36
ARKANSAS	138.81	154.77	154.03	39.1	40.2	39.8	3.55	3.85	3.87
Fayetteville—Springdale	130.07	142.04	140.54	39.9	39.9	39.7	3.26	3.56	3.54
Fort Smith	136.52	150.54	154.06	37.2	38.6	39.2	3.67	3.90	3.93
Little Rock—North Little Rock	157.19	175.47	176.51	39.2	39.7	39.4	4.01	4.42	4.48
Pine Bluff	169.60	186.24	200.38	38.9	40.4	41.4	4.36	4.61	4.84
CALIFORNIA	203.97	219.14	223.04	39.3	39.7	39.9	5.19	5.52	5.59
Anaheim—Santa Ana—Garden Grove	191.68	206.63	207.20	40.1	40.2	40.0	4.78	5.14	5.18
Bakersfield	199.56	215.77	210.35	38.9	38.6	37.9	5.13	5.59	5.55
Fresno	176.32	198.35	197.12	38.0	39.2	38.5	4.64	5.06	5.12
Los Angeles—Long Beach	192.57	205.88	209.44	39.3	39.9	40.2	4.90	5.15	5.21
Modesto	192.79	203.63	198.36	38.1	37.5	36.0	5.06	5.43	5.51
Oxnard—Simi Valley—Ventura	182.22	191.00	190.70	39.7	38.9	39.4	4.59	4.91	4.84
Riverside—San Bernardino—Ontario	205.88	229.25	231.95	39.9	39.8	40.2	5.16	5.76	5.77
Sacramento	220.38	233.14	240.95	38.8	38.6	39.5	5.68	6.04	6.10
Salinas—Seaside—Monterey	184.61	195.55	191.01	38.3	38.8	37.6	4.82	5.04	5.08
San Diego	194.43	211.53	213.40	38.5	38.6	38.8	5.05	5.48	5.50
San Francisco—Oakland	239.78	265.44	270.92	38.8	39.5	39.9	6.18	6.72	6.79
San Jose	218.79	246.58	250.04	39.0	39.9	40.2	5.61	6.18	6.22
Santa Barbara—Santa Maria—Lompoc	176.18	188.28	185.93	38.3	38.9	38.1	4.60	4.84	4.88
Santa Rosa	186.50	197.62	209.98	37.3	36.8	38.6	5.00	5.37	5.44
Stockton	218.79	236.02	232.54	39.0	39.6	38.5	5.61	5.96	6.04
Vallejo—Fairfield—Napa	206.45	223.82	228.51	37.4	38.0	38.6	5.52	5.89	5.92
COLORADO	194.24	206.06	212.26	39.4	39.4	40.2	4.93	5.23	5.28
Denver—Boulder	198.97	208.96	211.86	39.4	39.5	39.6	5.05	5.29	5.35
CONNECTICUT	191.68	206.25	208.59	40.1	40.6	40.9	4.78	5.08	5.10
Bridgeport	201.06	218.40	224.27	40.7	42.0	42.8	4.94	5.20	5.24
Hartford	214.56	231.44	233.38	41.5	41.7	41.9	5.17	5.55	5.57
New Britain	199.35	207.25	209.90	40.6	40.4	40.6	4.91	5.13	5.17
New Haven—West Haven	195.02	205.53	207.43	39.8	40.1	40.2	4.90	5.12	5.16
Stamford	199.58	216.11	216.62	40.4	41.8	41.9	4.94	5.17	5.17
Waterbury	164.40	183.84	185.15	40.0	41.5	41.7	4.11	4.43	4.44
DELAWARE	196.50	229.63	230.33	39.3	41.6	41.5	5.00	5.52	5.55
Wilmington	225.22	256.23	257.50	39.1	41.8	41.6	5.76	6.13	6.19
DISTRICT OF COLUMBIA:									
Washington SMSA	217.32	210.21	214.42	38.6	38.5	39.2	5.63	5.46	5.47
FLORIDA	161.19	173.38	173.40	39.8	40.7	40.8	4.05	4.26	4.25
Fort Lauderdale—Hollywood	155.62	169.49	173.29	39.2	39.6	40.3	3.97	4.28	4.30
Jacksonville	202.86	214.11	217.26	42.0	41.9	42.6	4.83	5.11	5.10
Miami	145.78	149.23	150.78	39.4	39.9	40.1	3.70	3.74	3.76
Orlando	163.17	174.58	177.02	41.1	40.6	40.6	3.97	4.30	4.36
Pensacola	194.81	217.33	211.84	41.1	42.2	41.7	4.74	5.15	5.08
Tampa—St. Petersburg	178.49	182.61	188.78	40.2	40.4	41.4	4.44	4.52	4.56
West Palm Beach—Boca Raton	191.02	204.47	209.10	40.3	41.9	42.5	4.74	4.88	4.92
GEORGIA	151.26	167.68	169.72	39.7	40.6	40.7	3.81	4.13	4.17
Atlanta	179.54	210.08	209.87	39.2	40.4	39.9	4.58	5.20	5.26
Savannah	191.78	216.72	226.37	41.6	43.0	43.2	4.61	5.04	5.24
HAWAII	175.28	193.55	192.27	39.3	38.1	39.4	4.46	5.08	4.88
Honolulu	170.61	181.42	183.35	38.6	36.8	38.6	4.42	4.93	4.75
IDAHO[1]	181.12	194.30	207.11	38.7	38.4	39.3	4.68	5.06	5.27

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976^{p}	JUNE 1975	MAY 1976	JUNE 1976^{p}	JUNE 1975	MAY 1976	JUNE 1976^{p}
ILLINOIS	$212.66	$233.29	(*)	39.6	40.5	(*)	$5.38	$5.77	(*)
INDIANA	216.37	243.95	$245.78	39.7	41.0	41.1	5.45	5.95	$5.98
Indianapolis	216.68	242.18	(*)	40.2	41.9	(*)	5.39	5.78	(*)
IOWA	213.15	231.20	232.18	39.4	40.0	40.1	5.41	5.79	5.79
Cedar Rapids	214.09	234.43	252.76	39.5	40.7	41.3	5.42	5.76	6.12
Des Moines	216.98	238.16	238.76	38.0	39.3	39.4	5.71	6.06	6.06
Dubuque	246.65	274.13	278.00	38.6	39.5	40.0	6.39	6.94	6.95
Sioux City	188.16	212.70	207.09	39.2	39.1	39.0	4.80	5.44	5.31
Waterloo—Cedar Falls	265.95	284.97	283.29	39.4	39.8	39.4	6.75	7.16	7.19
KANSAS	186.42	200.28	202.91	40.6	40.8	41.3	4.59	4.91	4.91
Topeka	190.02	183.74	190.80	40.2	40.3	41.0	4.73	4.56	4.65
Wichita	211.34	219.72	219.64	41.7	41.3	41.4	5.07	5.32	5.31
KENTUCKY	176.93	199.40	200.09	38.8	39.8	39.7	4.56	5.01	5.04
Louisville	212.22	232.80	236.16	39.3	40.0	40.3	5.40	5.82	5.85
LOUISIANA	194.14	217.24	223.13	40.7	41.3	42.1	4.77	5.26	5.30
Baton Rouge	245.86	276.87	282.01	42.1	42.4	42.6	5.84	6.53	6.52
New Orleans	185.10	205.25	216.52	39.3	39.7	41.4	4.71	5.17	5.23
Shreveport	180.09	185.78	196.30	41.4	40.3	41.5	4.35	4.61	4.73
MAINE	150.88	160.40	163.60	39.6	39.9	40.0	3.81	4.02	4.09
Lewiston—Auburn	127.38	140.30	140.66	38.6	39.3	39.4	3.30	3.57	3.57
Portland	160.37	169.62	173.75	39.5	40.1	40.5	4.06	4.23	4.29
MARYLAND	197.39	218.80	219.60	39.4	40.0	40.0	5.01	5.47	5.49
Baltimore	206.71	228.17	232.30	39.6	40.1	40.4	5.22	5.69	5.75
MASSACHUSETTS	173.21	188.47	188.87	39.1	40.1	40.1	4.43	4.70	4.71
Boston	191.18	207.43	209.27	39.5	40.2	40.4	4.84	5.16	5.18
Brockton	145.54	152.85	154.80	38.4	38.5	38.7	3.79	3.97	4.00
Fall River	124.96	137.90	138.90	35.5	36.1	35.8	3.52	3.82	3.88
Lawrence—Haverhill	167.42	181.94	181.37	39.3	39.9	39.6	4.26	4.56	4.58
Lowell	165.95	168.13	169.38	39.7	39.1	39.3	4.18	4.30	4.31
New Bedford	148.60	159.80	161.46	38.2	38.6	39.0	3.89	4.14	4.14
Springfield—Chicopee—Holyoke	173.05	188.73	190.01	39.6	40.5	40.6	4.37	4.66	4.68
Worcester	174.47	189.21	188.02	38.6	39.5	39.5	4.52	4.79	4.76
MICHIGAN	245.19	292.61	300.80	40.3	43.1	43.9	6.08	6.79	6.85
Ann Arbor	258.77	331.94	342.16	40.3	45.1	46.3	6.42	7.36	7.39
Battle Creek	266.75	282.51	282.57	42.1	41.4	41.5	6.34	6.82	6.81
Bay City	265.59	306.79	309.05	44.6	47.3	47.4	5.96	6.49	6.52
Detroit	259.77	311.24	321.35	40.1	43.5	44.7	6.48	7.16	7.19
Flint	274.60	353.35	357.35	40.4	47.0	47.1	6.80	7.52	7.59
Grand Rapids	203.95	224.26	227.93	39.5	40.4	40.5	5.16	5.55	5.63
Jackson	227.22	242.58	241.74	41.0	40.9	40.5	5.54	5.93	5.97
Kalamazoo—Portage	221.97	254.89	256.76	40.3	41.5	41.6	5.51	6.14	6.17
Lansing—East Lansing	248.48	332.05	323.73	40.2	45.8	44.9	6.18	7.25	7.21
Muskegon—Norton Shore—Muskegon Heights	217.69	248.66	248.11	40.5	41.7	41.4	5.38	5.96	5.99
Saginaw	281.52	346.47	348.50	40.7	44.7	44.6	6.92	7.75	7.81
MINNESOTA	198.86	214.49	215.28	39.3	39.5	39.5	5.06	5.43	5.45
Duluth—Superior	183.38	194.89	197.18	39.1	38.9	39.2	4.69	5.01	5.03
Minneapolis—St. Paul	212.40	228.10	230.26	39.7	39.6	39.7	5.35	5.75	5.80
MISSISSIPPI	140.54	150.84	152.76	39.7	39.8	40.2	3.54	3.79	3.80
Jackson	151.11	153.58	156.78	41.4	40.1	40.2	3.65	3.83	3.90
MISSOURI	187.07	204.00	205.31	39.3	40.0	40.1	4.76	5.10	5.12
Kansas City	209.47	237.39	240.12	39.3	41.0	41.4	5.33	5.79	5.80
St. Joseph	184.13	190.80	196.50	41.1	40.0	40.6	4.48	4.77	4.84
St. Louis	216.22	233.02	236.45	39.6	39.9	39.9	5.46	5.84	5.93
Springfield	159.44	174.99	177.06	38.7	39.5	39.7	4.12	4.43	4.45
MONTANA	189.74	231.45	230.68	36.7	39.7	39.5	5.17	5.83	5.84

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1975	JUNE 1976P
NEBRASKA	$181.96	$207.16	$208.47	41.0	41.6	42.7	$4.44	$4.98	$4.89
Lincoln	159.81	180.15	184.27	37.8	39.6	39.4	4.22	4.55	4.67
Omaha	199.21	223.47	228.80	40.9	42.0	42.5	4.87	5.32	5.38
NEVADA	200.26	204.75	219.06	38.0	37.5	39.4	5.27	5.46	5.56
Las Vegas	246.87	260.17	(*)	39.0	39.6	(*)	6.33	6.57	(*)
NEW HAMPSHIRE	154.06	165.57	166.76	39.3	39.8	39.8	3.92	4.16	4.19
Manchester [3]	142.40	153.66	151.71	38.8	39.5	38.8	3.67	3.89	3.91
Nashua [3]	175.08	182.40	184.80	39.7	40.0	40.0	4.41	4.56	4.56
NEW JERSEY	197.96	220.18	221.01	40.4	41.7	41.7	4.90	5.28	5.30
Atlantic City	146.43	160.01	162.80	35.2	36.7	37.0	4.16	4.36	4.40
Camden [3]	180.42	196.71	197.51	38.8	39.9	39.9	4.65	4.93	4.95
Hackensack [4]	190.87	204.22	204.11	39.6	40.2	40.1	4.82	5.08	5.09
Jersey City [4]	190.55	203.31	206.40	40.2	40.1	40.0	4.74	5.07	5.16
New Brunswick—Perth Amboy—Sayreville [4]	211.87	231.90	232.22	39.9	40.9	41.1	5.31	5.67	5.65
Newark [4]	205.18	229.52	229.30	41.2	42.9	42.7	4.98	5.35	5.37
Paterson—Clifton—Passaic [4]	192.10	208.38	207.40	40.7	42.7	42.5	4.72	4.88	4.88
Trenton	213.70	245.40	247.34	42.4	44.7	45.3	5.04	5.49	5.46
NEW MEXICO	144.67	158.77	156.02	39.1	40.4	39.8	3.70	3.93	3.92
Albuquerque	151.30	160.34	156.42	39.4	40.8	39.7	3.84	3.93	3.94
NEW YORK	190.12	206.98	207.38	38.8	39.5	39.5	4.90	5.24	5.25
Albany—Schenectady—Troy	198.18	223.02	223.31	39.4	41.3	40.9	5.03	5.40	5.46
Binghamton	185.09	196.65	193.05	40.5	41.4	40.9	4.57	4.75	4.72
Buffalo	230.10	266.80	272.54	39.2	41.3	41.8	5.87	6.46	6.52
Elmira	184.93	202.40	200.15	39.6	40.0	39.4	4.67	5.06	5.08
Monroe County [5]	237.69	270.28	264.38	40.7	42.1	41.7	5.84	6.42	6.34
Nassau—Suffolk [6]	187.46	195.42	196.02	39.3	39.4	39.6	4.77	4.96	4.95
New York—Northeastern New Jersey	187.20	201.17	(*)	39.0	39.6	(*)	4.80	5.08	(*)
New York and Nassau—Suffolk [6]	176.90	186.47	186.96	37.8	37.9	38.0	4.68	4.92	4.92
New York SMSA [6]	175.13	184.99	185.48	37.5	37.6	37.7	4.67	4.92	4.92
New York City [7]	173.72	182.77	183.26	37.2	37.3	37.4	4.67	4.90	4.90
Poughkeepsie	194.00	217.87	215.87	38.8	40.8	40.5	5.00	5.34	5.33
Rochester	228.83	257.49	251.52	40.5	41.8	41.3	5.65	6.16	6.09
Rockland County [7]	188.37	207.90	211.08	41.4	42.0	42.3	4.55	4.95	4.99
Syracuse	205.44	224.95	224.41	40.6	41.2	41.1	5.06	5.46	5.45
Utica—Rome	170.21	187.53	190.40	39.4	39.9	40.0	4.32	4.70	4.76
Westchester County [7]	183.53	199.87	200.09	39.3	39.5	39.7	4.67	5.06	5.04
NORTH CAROLINA	134.59	147.66	148.83	38.9	39.8	39.9	3.46	3.71	3.73
Asheville	133.72	146.03	147.97	39.1	39.9	40.1	3.42	3.66	3.69
Charlotte—Gastonia	133.08	152.07	152.03	38.8	41.1	41.2	3.43	3.70	3.69
Greensboro—Winston-Salem—High Point	147.06	158.79	160.38	38.7	39.5	39.5	3.80	4.02	4.05
Raleigh—Durham	150.93	161.85	162.24	38.6	39.0	39.0	3.91	4.15	4.15
NORTH DAKOTA	169.62	187.93	191.35	40.1	39.9	40.2	4.23	4.71	4.76
Fargo—Moorhead	182.51	202.19	203.77	40.2	40.6	41.0	4.54	4.98	4.97
OHIO	220.95	250.43	252.89	40.1	41.5	41.8	5.51	6.02	6.05
Akron	235.00	242.60	240.85	41.3	41.4	41.1	5.69	5.86	5.85
Canton	220.81	244.95	244.84	39.5	39.7	39.3	5.59	6.17	6.23
Cincinnati	209.20	231.54	234.89	40.7	41.2	41.5	5.14	5.62	5.66
Cleveland	224.80	259.30	263.30	40.0	42.3	42.4	5.62	6.13	6.21
Columbus	207.63	226.24	230.04	39.7	40.4	40.5	5.23	5.60	5.68
Dayton	232.47	268.27	264.31	41.0	43.2	42.7	5.67	6.21	6.19
Toledo	234.03	259.79	259.79	40.7	41.7	41.7	5.75	6.23	6.23
Youngstown—Warren	243.42	276.80	278.80	38.7	40.0	40.0	6.29	6.92	6.97
OKLAHOMA	174.32	187.13	190.35	39.8	39.9	40.5	4.38	4.69	4.70
Oklahoma City	175.96	192.23	190.95	39.9	40.3	40.2	4.41	4.77	4.75
Tulsa	189.77	210.48	208.55	39.7	40.4	39.8	4.78	5.21	5.24
OREGON	221.05	233.63	245.52	39.9	39.2	39.6	5.54	5.96	6.20
Eugene—Springfield	237.02	246.58	269.04	42.1	39.9	41.2	5.63	6.18	5.53
Jackson County	234.77	237.34	264.58	41.7	39.1	42.4	5.63	6.07	6.24
Portland	209.21	232.46	232.54	37.9	39.2	38.5	5.52	5.93	5.34

See footnotes at end of table.

C-13. Gross hours and earnings of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1976P	JUNE 1975	MAY 1976	JUNE 1975P
PENNSYLVANIA	$188.54	$207.76	$208.94	38.4	39.2	39.2	$4.91	$5.30	$5.33
Allentown—Bethlehem—Easton	188.98	199.54	201.22	38.1	38.3	38.4	4.96	5.21	5.24
Altoona	159.09	173.25	171.77	37.7	38.5	38.6	4.22	4.50	4.45
Delaware Valley [8]	198.27	221.45	220.73	38.8	39.9	39.7	5.11	5.55	5.56
Erie	203.77	210.60	208.64	41.0	40.5	40.2	4.97	5.20	5.19
Harrisburg	175.87	188.64	189.21	39.7	39.3	39.5	4.43	4.80	4.79
Johnstown	206.65	225.38	228.82	37.1	37.5	38.2	5.57	6.01	5.99
Lancaster	169.26	191.63	190.76	39.0	40.6	40.5	4.34	4.72	4.71
Northeast Pennsylvania	139.59	147.60	148.99	35.7	36.0	35.9	3.91	4.10	4.15
Philadelphia SMSA	196.33	218.25	217.56	38.8	39.9	39.7	5.06	5.47	5.48
Pittsburgh	225.03	254.29	255.91	39.0	40.3	40.3	5.77	6.31	6.35
Reading	172.77	187.46	187.77	39.0	39.3	39.2	4.43	4.77	4.79
Scranton [9]	140.79	145.20	148.83	36.1	35.5	36.3	3.90	4.09	4.10
Wilkes-Barre—Hazleton [10]	137.42	148.42	148.10	35.6	36.2	35.6	3.86	4.10	4.16
Williamsport	172.48	176.15	175.38	39.2	38.8	38.8	4.40	4.54	4.52
York	175.74	191.47	193.64	40.4	41.0	41.2	4.35	4.67	4.70
RHODE ISLAND	148.22	162.35	165.19	38.7	39.5	39.9	3.83	4.11	4.14
Providence—Warwick—Pawtucket	148.22	164.81	166.43	38.7	40.1	40.2	3.83	4.11	4.14
SOUTH CAROLINA [1]	140.54	153.12	155.07	39.7	40.4	40.7	3.54	3.79	3.81
Charleston—North Charleston [1]	160.00	173.66	173.72	40.2	40.2	40.4	3.98	4.32	4.30
Columbia [1]	141.74	151.70	153.26	38.0	39.2	39.5	3.73	3.87	3.88
Greenville—Spartanburg [1]	141.91	155.42	155.04	40.2	40.9	40.8	3.53	3.80	3.80
SOUTH DAKOTA	177.66	179.34	183.72	42.4	40.3	41.1	4.19	4.45	4.47
Sioux Falls	225.62	226.59	236.56	44.5	41.5	42.7	5.07	5.46	5.54
TENNESSEE	157.16	168.92	172.63	40.5	40.9	41.2	3.89	4.13	4.19
Chattanooga	170.54	178.70	185.59	40.8	40.8	41.8	4.18	4.38	4.44
Knoxville	178.35	202.45	206.59	39.9	41.4	41.4	4.47	4.89	4.99
Memphis	185.66	185.33	194.00	40.1	39.6	40.5	4.63	4.68	4.79
Nashville—Davidson	162.74	176.62	176.71	39.5	39.6	39.8	4.12	4.46	4.44
TEXAS	185.64	199.67	203.12	40.8	41.0	41.2	4.55	4.87	4.93
Amarillo	155.20	178.36	178.09	38.8	39.2	39.4	4.00	4.55	4.52
Austin	153.71	168.92	172.08	41.1	41.0	40.3	3.74	4.12	4.27
Beaumont—Port Arthur—Orange	235.73	272.00	275.65	38.9	40.0	40.3	6.06	6.80	6.84
Corpus Christi	202.57	210.76	206.93	43.1	38.6	37.9	4.70	5.46	5.46
Dallas—Fort Worth	175.82	183.82	186.00	40.7	40.4	40.7	4.32	4.55	4.57
El Paso	130.42	143.05	148.06	38.7	39.3	39.8	3.37	3.64	3.72
Galveston—Texas City	291.50	328.71	328.26	44.1	44.3	44.3	6.61	7.42	7.41
Houston	222.50	243.76	248.22	42.3	42.1	42.0	5.25	5.79	5.91
Lubbock	150.73	150.12	150.59	42.7	41.7	41.6	3.53	3.60	3.62
San Antonio	140.35	151.37	153.00	40.1	40.8	40.8	3.50	3.71	3.75
Waco	154.31	173.13	174.93	40.5	39.8	40.4	3.81	4.35	4.33
Wichita Falls	165.57	173.84	175.22	41.6	39.6	39.2	3.98	4.39	4.47
UTAH	153.54	160.22	158.65	38.1	38.7	38.6	4.03	4.14	4.11
Salt Lake City—Ogden	153.58	159.12	160.31	38.3	39.0	39.1	4.01	4.08	4.10
VERMONT	165.65	175.82	177.92	40.5	40.7	40.9	4.09	4.32	4.35
Burlington	184.91	207.83	207.27	41.0	42.5	42.3	4.51	4.89	4.90
Springfield	187.37	188.00	186.59	41.0	40.0	39.7	4.57	4.70	4.70
VIRGINIA	156.81	170.45	171.65	39.4	40.2	40.2	3.98	4.24	4.27
Lynchburg	152.87	180.18	170.34	39.4	40.4	39.8	3.88	4.46	4.28
Norfolk—Virginia Beach—Portsmouth	160.80	185.56	187.32	40.2	41.7	42.0	4.00	4.45	4.45
Northern Virginia [11]	198.18	185.94	186.58	39.4	38.9	38.0	5.03	4.78	4.91
Richmond	180.32	205.00	202.31	39.2	41.0	40.3	4.50	5.00	5.02
Roanoke	141.21	151.69	148.58	38.9	39.4	39.1	3.63	3.85	3.80
WASHINGTON	223.86	244.95	248.77	39.0	39.7	39.3	5.74	6.17	6.33
Seattle—Everett	231.67	253.04	253.62	39.4	39.6	39.2	5.88	6.39	6.47
Spokane	192.62	218.01	219.18	36.9	39.0	39.0	5.22	5.59	5.62
Tacoma	230.44	247.68	246.91	39.8	38.7	38.7	5.79	6.40	6.38
WEST VIRGINIA	189.83	213.33	213.05	38.9	40.1	39.6	4.88	5.32	5.38
Charleston	227.01	243.72	244.96	41.2	41.1	41.1	5.51	5.93	5.96
Huntington—Ashland	209.41	238.79	239.38	37.8	40.2	40.3	5.54	5.94	5.94
Parkersburg—Marietta [9]	206.58	232.15	235.91	39.2	40.8	41.1	5.27	5.69	5.74

See footnotes at end of table.

Table B-10 continued

ESTABLISHMENT DATA
STATE AND AREA HOURS AND EARNINGS

C-13. Gross hours and earning of production workers on manufacturing payrolls, by State and selected areas—Continued

State and area	Average weekly earnings			Average weekly hours			Average hourly earnings		
	JUNE 1975	MAY 1976	JUNE 1976p	JUNE 1975	MAY 1976	JUNE 1976p	JUNE 1975	MAY 1975	JUNE 1976p
WEST VIRGINIA—Continued									
Wheeling	$205.32	$219.54	$217.80	40.9	39.7	39.6	$5.02	$5.53	$5.50
WISCONSIN	210.86	228.77	227.66	40.2	40.6	40.3	5.25	5.63	5.64
Appleton—Oshkosh	199.98	217.88	222.30	40.7	41.1	41.4	4.92	5.30	5.37
Green Bay	218.39	228.25	232.27	41.7	41.0	41.7	5.23	5.56	5.56
Kenosha	286.66	260.61	255.93	43.3	39.2	38.4	6.62	6.65	6.66
La Crosse	189.80	198.95	189.90	42.1	41.8	40.5	4.51	4.77	4.69
Madison	234.77	248.47	245.32	40.2	40.3	39.7	5.85	6.17	6.18
Milwaukee	229.61	249.65	248.40	40.0	40.4	40.0	5.74	6.18	6.21
Racine	223.79	240.69	236.75	39.4	40.0	39.7	5.69	6.02	5.95
WYOMING	195.17	228.08	222.27	38.7	41.3	40.6	5.04	5.52	5.48
Casper	223.45	251.17	250.80	36.4	42.2	39.7	6.14	5.95	6.31
Cheyenne	185.07	270.81	233.64	31.0	33.0	29.9	5.97	8.20	7.81

[1] Based on 1972 Standard Industrial Classification.

[2] Initial publication in this table.

[3] Subarea of Philadelphia, Pennsylvania Standard Metropolitan Statistical Area: Burlington, Camden, and Gloucester Counties, New Jersey.

[4] Subarea of New York—Northeastern New Jersey.

[5] Subarea of Rochester Standard Metropolitan Statistical Area.

[6] Area included in New York and Nassau—Suffolk combined SMSA's.

[7] Subarea of New York Standard Metropolitan Statistical Area.

[8] Subarea of Philadelphia, Pennsylvania Standard Metropolitan Statistical Area: Bucks, Chester, Delaware, Montgomery, and Philadelphia Counties, Pennsylvania.

[9] Subarea of Northeast Pennsylvania Standard Metropolitan Statistical Area: Lackawanna County.

[10] Subarea of Northeast Pennsylvania Standard Metropolitan Statistical Area: Luzerne County.

[11] Subarea of Washington, D.C. Standard Metropolitan Statistical Area: Alexandria, Fairfax, Falls Church, Manassas, and Manassas Park cities, and Arlington, Fairfax, Loudoun, and Prince William Counties, Virginia.

p= preliminary.

* Not available.

SOURCE: Cooperating State agencies listed on inside back cover.

APPENDIX C

CORRELATION MATRICES, MEANS AND STANDARD DEVIATIONS OF VARIABLES USED IN THE SUPPLY MODELS

APPENDIX C

In this appendix, the following generic labels are used with reference to the model under consideration, viz.

N_W : white I-IIIA, DHSG, 17-21-year-old male accessions;

N_B : non-white I-IIIA, DHSG, 17-21-year-old, male accessions;

N_T : total I-IIIA, DHSG, 17-21-year-old, male accessions;

Q_W : white, I-IIIA, DHSG, 17-21-year-old, males who are not currently in school;

Q_B : non-white, I-IIIA, DHSG, 17-21-year-old males who are not currently in school;

Q_T : total, I-IIIA, DHSG, 17-21-year-old, males who are not currently in school;

R : recruiters assigned at station level;

U : general unemployment rate;

E : the index of civilian wage computed as the reciprocal of average manufacturing wage.

N_W, N_B, N_T, and R are specific to the service under consideration while Q_W, Q_B, Q_T, U and E are service-independent.

Table C-1

Army White Supply Model Correlations

	N_W	Q_W	R	U	E
N_W	1.0	.95	.96	.26	-.23
Q_W		1.0	.94	.19	-.37
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-2

Army Non-white Supply Model Correlations

	N_B	Q_B	R	U	E
N_B	1.0	.60	.59	.20	.26
Q_B		1.0	.88	.22	-.21
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-3

Army Total Supply Model Correlations

	N_T	Q_T	R	U	E
N_T	1.0	.92	.96	.27	-.16
Q_T		1.0	.95	.19	-.36
R			1.0	.21	-.25
U				1.0	.08
E					1.0

Table C-4

Means and Standard Deviations for Army Supply Variables

Variable	Mean	Standard Deviation
N_W	938.216	936.253
N_B	159.725	200.375
N_T	1097.94	1060.72
Q_W	12695.3	13464.0
Q_B	547.176	744.086
Q_T	13242.5	14075.3
R	96.333	98.835
U	8.41	2.136
E	.0055	.00087

Table C-5

Navy White Supply Model Correlations

	N_W	Q_W	R	U	E
N_W	1.0	.94	.97	.23	-.27
Q_W		1.0	.89	.19	-.37
R			1.0	.21	-.26
U				1.0	.08
E					1.0

Table C-6

Navy Non-white Supply Model Correlations

	N_B	Q_B	R	U	E
N_B	1.0	.87	.93	.19	-.12
Q_B		1.0	.86	.22	-.21
R			1.0	.21	-.26
U				1.0	.08
E					1.0

Table C-7

Navy Total Supply Model Correlations

N_T	N_T	Q_T	R	U	E
Q_T	1.0	.94	.97	.23	-.26
R		1.0	.90	.19	-.36
U			1.0	.21	-.26
E				1.0	.08
					1.0

Table C-8

Means and Standard Deviations for Navy Supply Variables

Variable	Mean	Standard Deviation
N_W	943.745	1006.90
N_B	80.7451	92.6871
N_T	1024.49	1092.23
Q_W	12695.3	13464.0
Q_B	547.176	744.086
Q_T	13242.5	14075.3
R	61.608	71.728
U	8.41	2.14
E	.0055	.00087

Table C -9

USAF White Supply Model Correlations

	N_W	Q_W	R	U	E
N_W	1.0	.93	.97	.28	-.24
Q_W		1.0	.93	.19	-.37
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-10

USAF Non-white Supply Model Correlations

	N_B	Q_T	R	U	E
N_B	1.0	.90	.85	.22	-.04
Q_B		1.0	.86	.22	-.21
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-11

USAF Total Supply Model Correlations

	N_T	Q_T	R	U	E
N_T	1.0	.93	.97	.27	-.22
Q_T		1.0	.94	.19	-.36
R			1.0	.23	-.20
U				1.0	.08
E					1.0

Table C-12

Means and Standard Deviations for USAF Supply Variables

Variable	Mean	Standard Deviation
N_W	781.000	802.627
N_B	85.9804	101.717
N_T	866.980	886.234
Q_W	12695.3	13464.0
Q_B	547.176	744.086
Q_T	13242.5	14075.3
R	26.843	27.880
U	8.41	2.14
E	.0055	.00087

Table C-13

USMC White Supply Model Correlations

	N_W	Q_W	R	U	E
N_W	1.0	.97	.96	.19	-.35
Q_W		1.0	.94	.19	-.37
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-14

USMC Non-white Supply Model Correlations

	N_B	Q_B	R	U	E
N_B	1.0	.86	.81	.20	-.08
Q_B		1.0	.87	.22	-.21
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-15

USMC Total Supply Model Correlations

	N_T	Q_T	R	U	E
N_T	1.0	.97	.97	.20	-.31
Q_T		1.0	.95	.19	-.36
R			1.0	.16	-.27
U				1.0	.08
E					1.0

Table C-16

Means and Standard Deviations for USMC Supply Models

Variable	Mean	Standard Deviation
N_W	371.765	394.738
N_B	63.4118	76.7609
N_T	435.176	455.957
Q_W	12695.3	13464.0
Q_B	547.176	744.086
Q_T	13242.5	14075.3
R	38.471	44.233
U	8.41	2.14
E	.0055	.00087

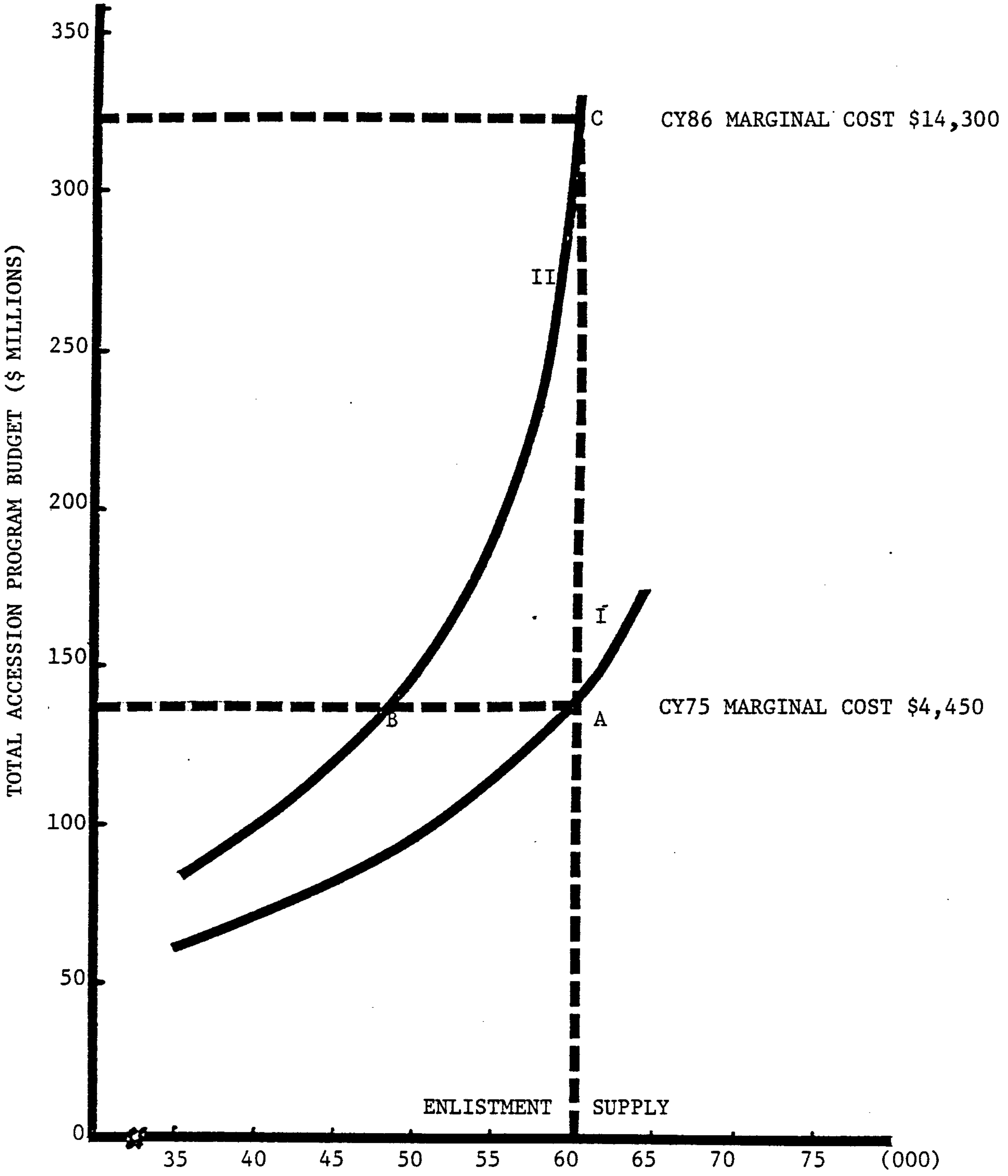

Fig. 6.2—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

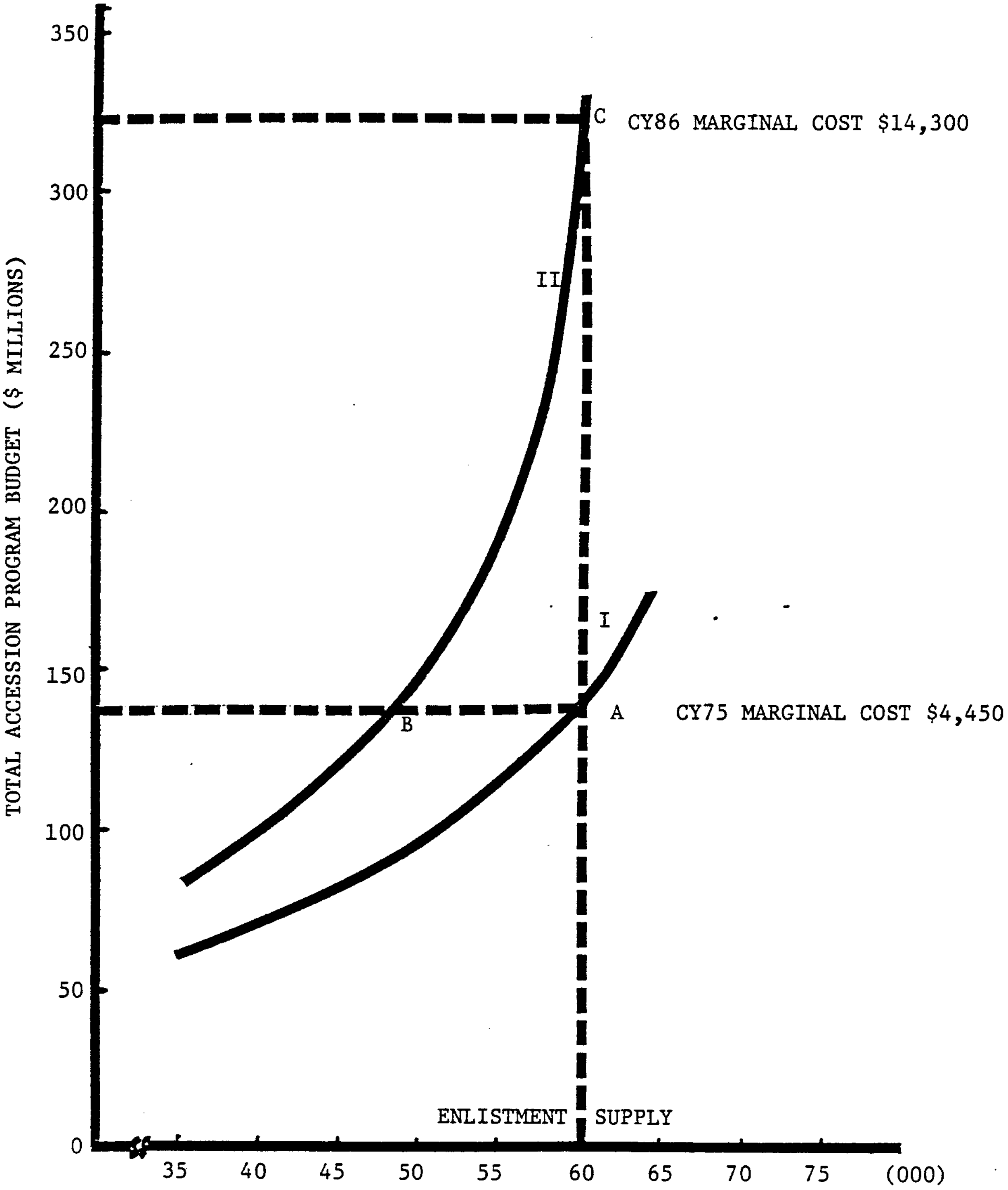

Fig. 1.3—Army Accession Production Functions
NPS Male, DHSG, I-IIIA

GRC DISTRIBUTION LIST

1 January 1975

Recipients of this document are indicated by ☒

	Address code	Agency	Number of copies
		DEPARTMENT OF DEFENSE	
☐	A1	Assistant Secretary of Defense (ISA)	1
☐	A2	Assistant Secretary of Defense (COMP)	1
☐	A3	Assistant Secretary of Defense (I)	2
☐	A4	Assistant Secretary of Defense (T)	1
☐	A5	Assistant Secretary of Defense (I&L)	1
☐	A6	Assistant Secretary of Defense (M&RA)	1
☐	A7	Assistant to the Secretary (AE)	1
☐	A15	Director, Defense Program Analysis & Evaluation	2
☐	A16	Director, Defense Research & Engineering	4
☐	A17	Director, Defense Communications Agency	1
☐	A18	Director, Weapons Systems Evaluation Group	1
☐	A19	Director, Defense Advanced Research Projects Agency	1
☐	A20	Director, Defense Nuclear Agency	1
☐	A21	Director, Defense Supply Agency	1
☐	A22	Director, National Security Agency	1
☐	A27	Director, Joint Staff (OJCS)	1
☐	A28	Joint Chiefs of Staff (SAGA)	1
☐	A29	Joint Chiefs of Staff (J-3)	1
☐	A30	Joint Chiefs of Staff (J-4)	1
☐	A31	Joint Chiefs of Staff (J-5)	1
☐	A32	Joint Chiefs of Staff (J-6)	1
☐	A37	Director, Defense Intelligence Agency	1
☐	A38	Defense Intelligence Agency (DI)	1
☐	A39	Defense Intelligence Agency (DT)	1
☐	A40	Defense Intelligence Agency (DE)	1
☐	A41	Defense Intelligence Agency (DC)	1
☐	A42	Defense Intelligence Agency (DS)	1
☐	A43	Defense Intelligence School	1
☐	A48	National War College	1
☐	A49	Industrial College of the Armed Forces	1
☐	A50	Armed Forces Staff College	1
☐	A51	National Military Command System Support Center	1
☒	A52*	Defense Documentation Center	2/12
		HEADQUARTERS, DEPARTMENT OF THE ARMY	
☐	B1	Deputy Under Secretary of the Army (OR)	1
☐	B2	Assistant Secretary of the Army (FM)	1
☐	B3	Assistant Secretary of the Army (I&L)	1
☒	B4	Assistant Secretary of the Army (M&RA)	1
☐	B5	Assistant Secretary of the Army (R&D)	1
☐	B10	Director of Army Staff	4
☐	B12	Assistant Chief of Staff for Intelligence	2
☐	B14	Deputy Chief of Staff for Personnel	1
☐	B15	Deputy Chief of Staff for Operations and Plans	2
☐	B16	Deputy Chief of Staff for Logistics	1
☐	B17	Deputy Chief of Research, Development, and Acquisition	1
☐	B19	Comptroller of the Army	1
☐	B21	Chief Engineers	1
☐	B22	Office of the Surgeon General (MI)	1
☐	B23	Directorate of Military Support	1
☐	B24**	The Army Library (ASDIRS)	1

*Required IAW AR 70-11 and AR 70-31. (12 copies for Open Literature cleared publications, and 2 copies for Limited Distribution publications.)

**Normally required; exclusion must be justified by Sponsor (AR 1-28).

The above represents entire distribution.