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A MODEL OF THE NATIONAL GUARD PERSONNEL SYSTEM: AN EXPLORATORY --ETC(U)

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**A RAND NOTE**

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**A MODEL OF THE NATIONAL GUARD PERSONNEL  
SYSTEM: AN EXPLORATORY ANALYSIS**

**William McNaught**

**June 1981**

**N-1612-MRAL**

**Office of the Assistant Secretary of  
Defense/Manpower, Reserve Affairs  
and Logistics**

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✓ This note presents a simple model of the National Guard personnel system. The model contains equations describing (1) the supply of nonprior service accessions; (2) the supply of prior service accessions; (3) the total strength of the National Guard; and (4) the demand for National Guard personnel. Results of the accession equations uphold prior studies reporting reservist supply to be inelastic. The demand equation results show National Guard authorizations to move from shortage areas to areas of relative oversupply. Although the model's exploratory nature prohibits any policy analysis based on its findings, the results suggest that the model's structure is a promising one for future Reserve research. 26 pp. (See also N-1562-MRAL and N-1563-MRAL, forthcoming). (WM)

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## A RAND NOTE

A MODEL OF THE NATIONAL GUARD PERSONNEL  
SYSTEM: AN EXPLORATORY ANALYSIS

William McNaught

June 1981

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Prepared For

Office of the Assistant Secretary of  
Defense/Manpower, Reserve Affairs  
and Logistics

**Rand**  
SANTA MONICA, CA. 90406

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

PREFACE

This note documents a study conducted under Task Order 79-III-1 as part of the Rand Manpower, Mobilization, and Readiness Program, sponsored by the Office of the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics)--OASD(MRA&L).

With manpower issues assuming greater importance in defense planning and budgeting, the Rand study program seeks to develop broad strategies and specific solutions for dealing with present and future defense manpower problems. The achievement of these goals requires the development of new methodologies for examining broad classes of manpower problems, as well as specific, problem-oriented research. In addition to analyzing current and future manpower issues, the program seeks to contribute to a better general understanding of the manpower problems confronting the Department of Defense.

The present note continues the study of the Reserve accessions process discussed in William McNaught and Corazon Francisco, The Supply of Enlistees to the Selected Reserve Forces, N-1562-MRAL, forthcoming. These two studies are part of an ongoing analysis of the Reserve manpower system. The results of this and related studies should prove of interest to everyone concerned with Reserve manpower issues.

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## SUMMARY

This note describes a simple model of the National Guard personnel system. The model contains equations describing (1) the supply of nonprior service (NPS) accessions, (2) the supply of prior service (PS) accessions, (3) the total strength of the National Guard, and (4) the demand for National Guard personnel. All four equations are estimated using simultaneous techniques to allow for interactions between each of the equations.

Although the results of this analysis are not strong enough to support policy pronouncements, they bear out the conclusion of earlier studies that Reserve supply is inelastic, i.e., relatively unresponsive to changes in pay rates. National Guard accession rates seem to respond to changes in recruiting effort, both in the National Guard itself (positively) and in the Army Reserve (negatively). This result, potentially very important to Reserve manpower policy, must be interpreted with care because of the difficulty of measuring effective Reserve recruiting efforts.

The results of this study suggest also that states which enlist higher percentages of prior service personnel have higher strength levels than states with more nonprior service intensive enlistment mixes. They also suggest that, over time, authorizations for National Guard personnel flow from areas of personnel shortages to areas of relative oversupply.

Models of this type appear promising for future Reserve research. Models of the total Reserve personnel system facilitate analysis by considering enlistment behavior jointly with other aspects of Reserve service. Such models more easily encompass both important approaches to reservist behavior--sociological theories emphasizing friendships between reservists and economic theories emphasizing monetary incentives. Future Reserve models should be disaggregated below the level of states. Analysis is probably best conducted at the level of the individual Reserve unit.



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## INTRODUCTION

The Reserve forces have assumed an increasing share of the nation's defense burden. As the size of the active force has decreased during the 1970s, the nation has adopted a Total Force strategy explicitly recognizing the importance of the Reserve forces. Recent changes in force structure, such as the establishment of a Rapid Development Force, have increased the requirements for strategic airlift and ground combat forces, both of which rely heavily on Reserve units.

Despite this growing need for Reserve capability, Reserve force strength decreased during the early years of the all volunteer force (AVF), falling from 919,000 in FY73 to 788,000 in FY78. Although this decline was reversed in FY79 and FY80, when the number of reservists climbed to 850,000, rebuilding Reserve strength to pre-AVF levels still presents a formidable policy challenge.

A key issue in that rebuilding process is the extent to which reservists respond to monetary incentives. The success of the active force in maintaining strength in an AVF has been attributed largely to volunteer responsiveness to increases in compensation. This responsiveness, predicted by research prior to the AVF, formed the basis for the level of pay increases given to sustain the AVF [1].

In the absence of measurements of Reserve responsiveness to pay increases during the AVF planning, it was assumed that reservists and active accessions would respond similarly, that is, that similar military jobs would be associated with similar supply characteristics. Little evidence exists to support this assumption of similarity.

The conditions of service in the Reserve and in the active force differ, and therefore supply characteristics also differ. First, because reservists serve only part-time, supply behavior is inevitably linked to the reservist's full-time job. Second, Reserve units are more self-contained and stable than active force units, because both

Reserve units and their personnel are tied to a particular geographic area, whereas members of active force units periodically rotate to new assignments. Third, Reserve units may fulfill a community service as well as a military function. For example, National Guard units are often called upon to assist during disasters or periods of civil unrest.

Studies of reservist behavior have not achieved a consensus about the value of the Reserve pay elasticity. The first such study, by Bernard Rostker [2], examined data on Air Force Reserve enlistments during the draft era and concluded that the Reserve pay elasticity exceeded unity. A second study, by Robert Kelly [3], used cross-sectional data on all enlistments to all selected Reserve components during 1977. Kelly estimated a much lower Reserve pay elasticity—.20 for nonprior service (NPS) personnel and .35 for prior service (PS) personnel. Finally, a study by this author and Corazon Francisco [4], using methods analogous to Kelly's, obtained point estimates similar in magnitude to Kelly's; however, these estimates were not precise enough to rule out the possibility that the Reserve pay elasticity was, in fact, greater than one.

Definitive estimates will require additional research. This note seeks to contribute to that research, using insights developed in prior research to extend the model of reservist supply. Instead of analyzing the supply of Reserve personnel to all six Reserve components, the note focuses on the demand for and supply of personnel to the National Guard. It shows that the enlistment functions of each Reserve component depend on the recruiting efforts undertaken by other components.

The second section of this note reviews the recommendations of prior research on the Reserve forces and examines the advantages and disadvantages of using only a single Reserve component for analysis, rather than the entire supply of enlistees to all six components. Finally, it describes the model and the theory behind each of its parts.

The third section of the note presents the detailed equations of the model and their estimated coefficients and discusses the implications of the results for future Reserve research. These results must be considered tentative; they are presented here not for use in any policy context, but rather to suggest the avenues that appear promising for future Reserve manpower research.

## II. MODEL OVERVIEW

Prior analyses of selected Reserve enlistments have contributed some insights about the nature of Reserve supply, but still have not produced a reliable estimate of the elasticity of Reserve supply with respect to military pay. This parameter is a key to the establishment of a Reserve compensation policy.

At the conclusion of The Supply of Enlistees to the Selected Reserve, McNaught and Francisco suggested that to improve Reserve research, researchers should:

- o Account for both social and pecuniary factors in their models.
- o Embed accession analysis in a model of the total personnel system.
- o Analyze at the finest level of detail possible.
- o Address interactions between the components.

Social as well as pecuniary motivations are important because of the unique character of Reserve units. Their close association with a particular community or area gives their members a sense of satisfaction not unlike that achieved by membership in a voluntary service organization. The esprit de corps common in any effective military unit reinforces this aspect of Reserve service.

A model only of Reserve accessions supply will not suffice, because the personnel systems of all the selected Reserve components are highly decentralized. Decentralization blurs the boundaries between the personnel functions. In particular, it becomes impossible to consider any single policy or behavior apart from the entire personnel system. We argue below that accession rates depend on current strength levels. Strength levels, in turn, depend on prior

retention experience. If reservists value the status accompanying selection to a higher grade, retention will depend on promotion policy. Promotions may reflect vacant positions. Vacant positions may be moved from areas of low strength to areas with higher accession rates. The procedure, customary in active force analysis, of examining individual facets of the personnel system in isolation, although dubious even there, may be seriously misleading for Reserve analysis.

All prior Reserve analyses have used either the state or the nation as the geographic unit of observation. Yet Reserve units recruit in local labor markets usually no larger than a standard metropolitan statistical area (SMSA), often much smaller. Disaggregation to smaller observation units is necessary to overcome the aggregation bias inherent in previous analyses.

This note describes a prototype effort demonstrating the feasibility of a disaggregated Reserve manpower model. The data sources are similar to those used by McNaught and Francisco and by Kelly. The ready accessibility of the data sources substantially reduces the time and cost of the analysis. Unfortunately, these data use states as the units of observation. Although individual Reserve units are the proper observation units for Reserve supply analysis, the continued use of state-based data demonstrates the utility of this type of extended model for Reserve research. This model could easily be adapted to a larger data base developed from data describing individual Reserve units.

Both the Kelly and the McNaught and Francisco studies of Reserve manpower supply measured supply in terms of total enlistees to all selected Reserve components in a state. McNaught and Francisco argued that (1) to the extent that these enlistments were independent random variables, this aggregation would reduce sampling error and (2) Reserve recruiting efforts were interdependent and each component tended to establish its own prime recruiting areas. Thus, analysis of a single component's recruiting efforts would be biased.

An ideal model would examine each of the components individually, then integrate all six examinations into a larger framework. The construction of such a complex model was not practical in an exploratory effort such as this.

Given the limitations of including only a single component in this analysis, the National Guard--the largest of the six components, comprising 43 percent of all reservists--is the obvious choice. Because of its size, the National Guard recruits actively in every state, and its supply of recruits is probably less sensitive to changes in the recruiting activities of other components than are the supplies of recruits to the other Reserve components. The National Guard is experiencing personnel shortages--3.6 percent in FY79--as severe as those in any component except the Army Reserve. Finally, the personnel data maintained by the National Guard are of superior quality to those of most of the other components.

Although the model is limited to the analysis of the National Guard personnel, it includes the effects of recruiting changes in the Army Reserve on National Guard accession rates. The Army Reserve is a major competitor for the types of personnel that usually enter the National Guard. By including a measure of Army Reserve recruiting effort, the model captures at least some of the interactions between the supply functions of the various components. Further research could develop this model into a fully simultaneous model of the supply systems of all six selected Reserve components.

The remainder of this section summarizes the specifications of the model, discussing, first, the equations for NPS and PS accessions; second, the retention equation linking accessions to total Reserve strength levels; and third, the demand for National Guard personnel and the Reserve authorization process. The section concludes with a summary of the model's components.

#### THE ACCESSION EQUATIONS

Because the specification of the accession equations parallels closely the specifications used by Kelly and by McNaught and Francisco, I will describe them here only briefly.



The supply equations are based on the simple theory of moonlighting behavior first presented by Robert Shishko and Bernard Rostker [5]. This theory suggests that four variables are important to the Reserve accession decision: (1) Reserve pay, (2) pay on the primary job, (3) hours worked on the primary job, and (4) pay opportunities in alternative secondary employment. Measures of all four variables are included in the accession equations. (The nine equations of the model are listed on page 11, below). Because no measure of wages in moonlighting jobs is available, I use a measure of wage rates in all secondary jobs instead.

As additional variables, the accession equations include unemployment, population proxies for recruiting activity, and regional dummies. The unemployment measure is included because time series analysis shows that the NPS accession decision is significantly affected by fluctuations in unemployment rates [6]. Population is included as a scale factor. In other words, the model analyzes rates of Reserve accessions from a given population base, defined here as all males ages 18 to 26 for NPS accessions and all veterans regardless of age and sex for PS accessions.

Two types of recruiting proxies are included in each accession equation. Most of the studies of active force manpower supply have found the number of military recruiters to be directly related to observed accession rates. Given the importance of social factors, as argued above, the model assumes that most Reserve members are recruited through informal contacts between participating reservists and their friends in the community. Thus, the best measure of recruiting activity is the ratio of currently participating reservists to the eligible population base. To avoid simultaneity bias, the number of National Guardsmen in the preceding year is used in the numerator of this ratio. If the current-year figure were used, new accessions would appear both as a dependent variable and as part of the independent variable, creating a spurious correlation between the two variables. To measure the recruiting activity of the Army Reserve, the model uses a similar proxy for its contacts, namely, the ratio of participating Army Reservists to the eligible population base.

Finally, the model includes dummy variables for three of the four census regions to capture possible shifts in the taste for military service across the United States.

#### THE RETENTION EQUATION

The supply of reservists depends both on the decision to join, made by incoming personnel, and on their decision to continue Reserve service at the expiration of each enlistment term. In other words, the stock of current reservists is the product of the history of accessions and the continuing retention decisions of these accessions.

Because the stock of current reservists is the best measure of trained Reserve manpower available as inputs to the production of defense services, this is the supply variable of foremost interest to Reserve planners. Although Reserve accession problems receive more attention, low retention rates may be an equally important cause of Reserve strength shortages. In fact, a recent Defense Department study pinpointed retention as the key Reserve manpower problem [7].

Only a model of the complete Reserve personnel system could examine the implicit trade-offs between accessions and retention. Successful accession programs can offset low retention patterns. Although the resulting force has a high turnover rate, it can still meet strength goals. Alternatively, the force can be designed with low flow rates and high experience levels. In this force, successful retention programs reduce the need for accessions.

The model's third equation is an accounting relation representing Reserve retention behavior. It specifies that current Reserve strengths are determined from prior accessions histories. Data on accessions for 1975 and 1976 are used in the equation (such data were unavailable before then), and the 1974 level of Reserve strength serves as a proxy for the combined accessions and retention experience of all prior years.

Although any rigorous treatment of retention behavior should include economic motivations, retention modeling is a full project in itself, far beyond the capabilities of this initial effort. This

accounting formulation provides the link between accessions and total personnel strength needed to close the model. Enough Reserve analysis is now under way to enable this part of the model to be extended in the near future [8].

#### THE DEMAND EQUATION

Equally crucial to the Reserve personnel system is the authorization system, which sets the demands for Reserve personnel. Figure 1 indicates the importance of this facet of the personnel system, using a Lorenz curve to show the cumulative percentage of authorizations for National Guard (ARNG) personnel in terms of the cumulative percentage of the population in the 50 states and the District of Columbia. The figure also displays the authorization distribution of the Army Reserve (USAR) as a standard of comparison.

Figure 1 shows that states containing only 8 percent of the population account for 20 percent of all National Guard authorizations. As the distribution of authorizations grows more unequal, the ARNG curve (as well as the USAR curve) bows out farther from the 45-degree line. Only if the distributions were perfectly fair with respect to population would the Lorenz curve coincide with the 45-degree line. The bow indicates the extent to which authorizations are allocated unequally among states. The inequality is greater for National Guard authorizations than for the authorizations of any of the other five components.

Analysis of the distribution of National Guard authorizations show that small states have a much higher authorization level, measured as a percentage of the population, than large states. Each of the 14 states that together contain 20 percent of all National Guard authorizations but only 8 percent of the national population has a population below the national average. Alabama has a level of authorizations exceeding that of Pennsylvania, a state three times its size, and a level of assigned reservists exceeding that of New York, nearly five times its size.

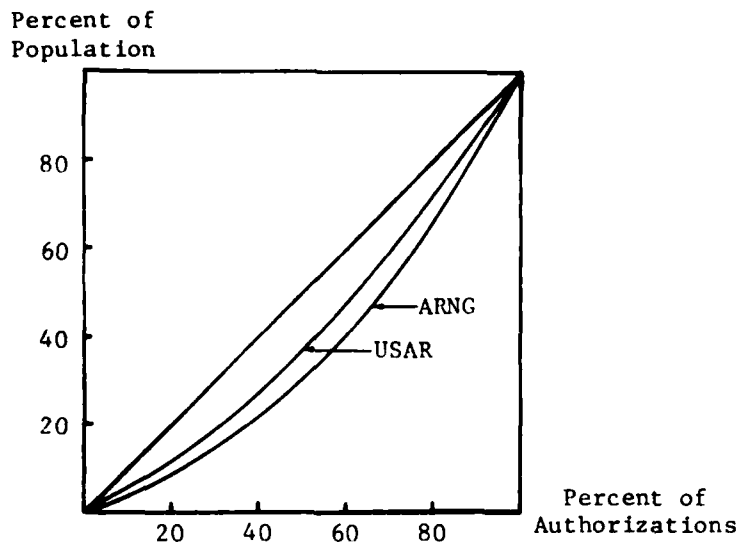


Fig. 1--Distribution of authorizations for the Army National Guard and Army Reserve

The inclusion of a demand equation for military personnel is the most original element of this model. Active force personnel models have generally avoided this obvious step [9]. The Reserve personnel system offers an almost unique opportunity to further this type of analysis, because the Defense Department's demands for reservists exceeded the number of participating reservists in every state in 1976.

The demand equation provides a bridge between Reserve personnel supply and operational concerns. A fully developed demand submodel might examine the impacts on reservist behavior of changes in the mission of the Reserve forces or changes in budget allocations. Any demand model will remain primitive until substantial additional research has addressed these important questions [10].

# MODEL SUMMARY

The full model of the National Guard personnel system can be summarized as follows:

$$A_t^N = f_1(M_t^N, C_t^N, S_t^N, P_t^N, R_t^N, V_t^N, U_t, H_t, X_t) \quad (1)$$

$$A_t^P = f_2(M_t^P, C_t^P, S_t^P, P_t^P, R_t^P, V_t^P, U_t, H_t, X_t) \quad (2)$$

$$Q_t = f_3(A_{t-1}^N, A_{t-1}^P, A_{t-2}^N, A_{t-2}^P, Q_{t-3}) \quad (3)$$

$$D_t = f_4(D_{t-1}, F_{t-1}) \quad (4)$$

$$F_{t-1} = \frac{Q_{t-1}}{D_{t-1}} \quad (5)$$

$$R_t^N = \frac{Q_{t-1}}{P_t^N} \quad (6)$$

$$R_t^P = \frac{Q_{t-1}}{P_t^P} \quad (7)$$

$$V_f^N = \frac{Z_{t-1}}{P_t^N} \quad (8)$$

$$V_f^P = \frac{Z_{t-1}}{P_t^P} \quad (9)$$

where  $A_t^N$  is the number of NPS accessions in year t  
 $A_t^P$  is the number of PS accessions in year t  
 $M_t^N$  is the present value of Reserve pay to an NPS accession in year t  
 $M_t^P$  is the current value of Reserve pay to a PS accession in year t  
 $C_t^N$  is the present value of primary pay for an NPS accession in year t

$C_t^P$	is the current value of primary pay for a PS accession in year t
$S_t^N$	is the present value of secondary wages for an NPS accession in year t
$S_t^P$	is the current value of secondary wages for a PS accession in year t
$P_t^N$	is the pool of potential NPS enlistees in year t
$P_t^P$	is the pool of potential PS enlistees in year t
$R_t^N$	is a proxy for NPS recruiting effort by the National Guard in year t
$R_t^P$	is a proxy for PS recruiting effort by the National Guard in year t
$V_t^N$	is a proxy for NPS recruiting effort by the Army Reserve in year t
$V_t^P$	is a proxy for PS recruiting effort by the Army Reserve in year t
$Z_{t-1}$	is the enlisted strength level of the Army Reserve in year t-1
$U_t$	is the unemployment rate in year t
$H_t$	is the primary hours worked in year t
$X_t$	are regional dummies
$Q_t$	is the enlisted strength level of the National Guard in year t
$D_t$	is the authorized strength level of the National Guard in year t
$F_{t-1}$	is the relative supply of National Guard reservists in year t-1

The first four equations are stochastic. The final five are identities which define the variables here called relative supply,  $F$ , and Reserve representation,  $R$ . The relative supply variable is simply the fraction of enlisted authorizations currently filled.

The Reserve representation variables are defined as ratios of the number of participating reservists in each component divided by the eligible population base--males ages 18 to 24 for NPS analysis and all veterans for PS analysis. Although, for reasons explained above, this variable is interpreted here as a measure of recruiting effort, other interpretations are also possible. For example, the Reserve representation variable could be a crude measure of the esprit de corps of the Reserve units in the state. The management of each unit changes only slowly over time. Assuming recruits prefer effective, well-run units, units which recruited well in prior periods would continue to recruit well in current periods. High recruiting and retention experience leads directly to higher relative strengths in the current period.

These Reserve representation variables are included in the model, despite their ambiguity, in an attempt to join the sociological theories of the effect of friendships and social status acquired through Reserve service [11] with an economic model of trade-offs between income and leisure time. Personal interviews with reservists and prior studies estimating inelastic reservist supply behavior suggest that reservist behavior is too complex to be analyzed with a model including pecuniary incentives only.

The model assigns to the current stock of participating reservists the key role in the personnel system. It assumes that the authorization process plays a passive role. As in Say's Law, supply creates its own demand. This assumption would appear to be accurate in the environment of falling Reserve strengths which prevailed in 1977 when the data for this analysis was collected. If Reserve strength trends reverse themselves as they are projected to do in the 1980s, this assumption of supply dominance would have to be altered and a truly simultaneous model developed.

### III. RESULTS

This model uses cross-sectional data for all 50 states and the District of Columbia. The base year, year  $t$  in the equations (1) through (9), is 1977. The major data sources for the variables in this equation set are described below in the first subsection. The second subsection presents the results and compares these new findings with prior ones. Finally, the significance of these new results for future Reserve manpower analysis is noted.

#### DATA SOURCES

The primary data source for Reserve personnel information is the Reserve Components Common Personnel Data System (RCCPDS) maintained by the Reserve Affairs Directorate of the Office of the Secretary of Defense. This system, begun in March 1973, became the official source of Reserve strength figures in July 1974 and of all personnel transactions (principally gains and losses) in July 1976.

Published accessions data from the RCCPDS are highly aggregated; therefore, I constructed a five-way classification--by state, mental category [12], sex, education, and type (i.e., NPS and PS)--of Reserve accessions in 1977 from individual RCCPDS computer records. Because this classification includes four mental categories and two education levels (high school graduate and non-high school graduate), the accessions matrix had 1632 cells.

In the NPS case, supply is defined as all male high school graduate enlistments in mental categories I through III. In the PS case, supply includes all enlistments, male and female, regardless of mental category or educational attainment. These definitions agree with those conventionally used in active force analysis and by other Reserve analysts.



The restriction of the analysis to only a subset of all NPS accessions is necessary to identify the supply equations. The model assumes that NPS enlistees from the omitted groups--females, Category IV personnel, and non-high school graduates--are less preferred by military recruiters than male high school graduates, Category I through III NPS enlistees, and all PS enlistees. Because some enlistees in the less preferred groups are observed in each state, we can be confident that our accession equations capture true supply behavior and are not confounded by demand restrictions.

The RCCPDS is also the source of all National Guard and Army Reserve strength data used in the model. All participating enlisted reservists are included in the strength figures. The remaining military variables --veteran population and enlisted authorizations--were obtained from unpublished data maintained by the Defense Manpower Data Center and the National Guard Bureau, respectively.

The Survey of Income and Education (SIE)[13] conducted by the Bureau of the Census in 1976 provided the income variables in the model. Because NPS male enlistees to the Selected Reserve incur a six-year service obligation, present value measures of income received and income foregone during the enlistment term must be constructed. The formulas for the three present values used in the model are shown in equations (10) through (12):

$$V_F = \sum_{t=1}^h \frac{C(1+r)^t}{(1+d)^t} \quad (10)$$

$$V_S = \sum_{t=1}^h \frac{S(1+r)^t}{(1+d)^t} \quad (11)$$

$$V_M = \frac{T - \frac{1}{2}(C+M)}{(1+d)} + \sum_{t=2}^h \frac{M(1+m)^t}{(1+d)^t} \quad (12)$$

where  $V_F$  = 1977 present value of mean income of full-time male workers  
 $V_S$  = 1977 present value of mean income of part-time male workers  
 $V_M$  = 1977 present value of a Reserve enlistment  
 $C$  = real mean income of full-time male workers in 1977  
(adjusted from 1975 levels)[14]  
 $S$  = real mean income of part-time male workers in 1977  
(adjusted from 1975 levels)[14]  
 $T$  = pay received during initial active duty for training  
 $M$  = real income of reservists in 1977  
 $r$  = annual growth rate in civilian income  
 $d$  = subjective discount rate of enlistees  
 $h$  = length of the enlistment term (fixed at six years)  
 $m$  = annual growth rate in military pay

Equation (12) is slightly more complex, because the NPS recruit spends the initial six months in full-time training. The discount rate used was 20 percent. Sensitivity tests of the model for other rates from 5 to 30 percent did not produce significantly different results. The assumed growth rate in military pay was 7.05 percent, the actual size of the pay raise received by military personnel in October 1977.

The data for primary hours worked and unemployment rates are annual averages derived from monthly Bureau of Labor Statistics data [15]. They represent all nonsupervisory, nonagricultural workers in the private economy. Finally, population data for 18- to 24-year-old males was taken from Current Population Survey information [16].

#### ESTIMATES OF THE COEFFICIENTS

Before the model can be estimated, each of the four stochastic relations must be cast in a functional form. For the two accessions equations, a logistic form common to the analysis of qualitative choice is used; the retention and demand equations are cast in simple linear terms.

The model is not strictly simultaneous, because all independent variables are predetermined. However, errors can be correlated across equations. Proper estimation calls for a generalized procedure to account for this correlation across equations. Table 1 displays the results of applying the Zellner technique [17] for estimating seemingly unrelated regressions to the data.

Although many of the resulting coefficients are not significant, most agree with a priori expectations. The NPS accession results, in particular, agree with those obtained both by Kelly and by McNaught and Francisco. Given the similarity of the data base used in all three studies, this is not surprising. Still, the differences in model specification and definition of the dependent variables are large enough that these results offer some additional corroboration of the hypothesis that NPS reservist supply is, in fact, inelastic and unresponsive to military pay rates.

Table 2 compares the most important results of the model, its estimates of the various elasticities of reservist supply, with the prior values cited by Kelly and by McNaught and Francisco. Of the pay elasticities for the National Guard, only the military pay elasticity for PS accessions exceeds one. This result agrees with the estimate obtained by McNaught and Francisco. Kelly's estimate is much lower. Since none of these elasticity values is statistically significant, probably the safest observation about the PS military pay elasticity is that it exceeds the NPS elasticity. The NPS military pay elasticity is actually negative (but not significant). The relatively small negative value of the NPS elasticity obtained here is not unreasonably different (within one standard error) from the small positive values obtained by Kelly and by McNaught and Francisco.

Table 1

COEFFICIENT ESTIMATES OF THE NATIONAL GUARD MODEL USING  
A SEEMINGLY UNRELATED REGRESSIONS PROCEDURE

Independent variable	Log( $\frac{\text{NPS rate}}{1-\text{NPS rate}}$ )		Log( $\frac{\text{PS rate}}{1-\text{PS rate}}$ )	
Military pay <sup>a</sup>	-.1131	.2521 <sup>b</sup>	1.3474	.7651
Primary pay <sup>a</sup>	-.0275	1.060	-.0248	.0366
Secondary pay <sup>a</sup>	-.8075	1.887	-.0665	.0391
Unemployment	-.0880	.0447	-.0472	.0297
Hours worked	.0362	.0525	.0550	.0420
Reserve representation, ARNG	.4801 <sup>c</sup>	.0678	.4143 <sup>c</sup>	.0480
Reserve representation, USAR	-.3567 <sup>c</sup>	.0904	-.2797 <sup>c</sup>	.1015
Northeastern region	.0265	.1796	.6673 <sup>c</sup>	.1348
Southern region	.1773	.1694	.0816	.1370
Northcentral region	-.0673	.2030	.1948	.1532
Constant	-7.8554 <sup>c</sup>	2.086	-5.219 <sup>c</sup>	1.660
Mean of dependent variable	-1627.8		-2048.2	
Standard error of regression	93.76		232.5	
	Strength 1977		Authorizations 1977	
NPS accessions, 1976	-.1123	.3197	--	
PS accessions, 1976	1.456 <sup>c</sup>	.3078	--	
NPS accessions, 1975	.3463	.5948	--	
PS accessions, 1975	.7764 <sup>d</sup>	.3219	--	
Strength, 1974	.4744 <sup>c</sup>	.0456	--	
Authorizations, 1976	--		1.0071 <sup>c</sup>	.0068
Relative supply, 1976	--		760.77 <sup>d</sup>	319.2
Constant	-22.497	104.5	-620.76 <sup>d</sup>	273.3
Mean of dependent variable	6064.5		8422.2	
Standard error of regression	497.7		278.6	

<sup>a</sup>For the NPS equation, the present value is measured in millions of dollars; for the PS equation, in thousands of dollars.

<sup>b</sup>Standard errors are shown in italics.

<sup>c</sup>Significant at the 1 percent level.

<sup>d</sup>Significant at the 5 percent level.

Table 2  
COMPARISON OF THE ESTIMATES OF RESERVIST SUPPLY ELASTICITIES

	National Guard-McNaught		DOD-McNaught & Francisco		DOD-Kelly	
	NPS	PS	NPS	PS	NPS	PS
Military pay	-.38	1.22	.01	1.48	.20	.35 <sup>a</sup>
Primary pay	-.01	-.36	-.21	-.21	-.20	-.35 <sup>a</sup>
Secondary pay	-.13	-.37	-.19	-.50	---	---
Reserve representation, National Guard	1.00	.86	---	---	---	---
Reserve representation, Army Reserve	-.31	-.24	---	---	---	---

<sup>a</sup>The functional form adopted by Kelly forced the two elasticities of reservist supply with respect to military and primary pay to be identical in absolute value.

All the civilian pay elasticities evidence the correct sign, but are small in magnitude. The largest National Guard (absolute) value is -.37. All four values estimated here are consistent with the range of elasticities, -.19 to -.50, reported by Kelly and by McNaught and Francisco.

Finally, the Reserve representation elasticities, not found in Kelly's and in McNaught and Francisco's work, are much larger than nearly all the pay elasticities. As shown in Table 1, the Reserve representation variables have by far the highest t statistics in the accession regressions. This outcome is consistent with the conventional wisdom of Reserve force managers that noneconomic factors, such as social ties between participating reservists and prospective recruits or unit management efficiency, are important elements in any Reserve supply decision. A complete model of reservist supply behavior must encompass these important social linkages, although the omission of such factors does not seem to bias the estimated coefficients for the pay elasticities.

The proxy for the Army Reserve recruiting effort, the Army Reserve representation variable, is also significant at the 1 percent level. Its negative sign suggests that successful Army Reserve recruiting campaigns do adversely affect National Guard accession rates for either NPS or PS personnel. The elasticity associated with

the Army Reserve representation variable is much lower than that of the corresponding National Guard variable. The magnitude of the Army Reserve representation elasticity is comparable to the magnitude of the pay elasticities.

The signs of the coefficients for unemployment and hours worked differ from our expectations. All four coefficients in both the NPS and PS equations are insignificant. Only one of the six regional dummies is significant. The pattern of these coefficients is distinctly different in two equations, suggesting that the supply behavior of NPS and PS personnel varies among areas of the country.

Unfortunately, the coefficients of the strength equation cannot be interpreted as retention rates. Such an interpretation would be possible only if one actually compared inventories in year  $t$  and year  $t-1$ , individual by individual. Still, values above 1 for PS accessions and as low as .35 and -.11 for NPS accessions suggest that it is NPS personnel, not PS personnel, who exhibit high turnover rates. A related interpretation of these findings would be that states in which Reserve strengths are declining find it easier to increase NPS rather than PS accessions to compensate for their losses.

Finally, the equation explaining authorizations verifies the suspicion that states with a relatively large number of reservists gain in authorizations over time at the expense of states experiencing shortages. Except for this shift to areas of better supply, authorizations seem remarkably stable from one year to the next, growing at a rate of less than one percent between 1976 and 1977.

#### SUGGESTIONS FOR FURTHER RESEARCH

The results of the study buttress earlier findings that reservist supply is inelastic. Despite the Defense Department's need for accurate assessments of the efficacy of pay increases for filling Reserve units, analysis of this point, including the analysis presented here, must be considered inconclusive. None of the three studies that estimated an inelastic Reserve supply function has obtained strong, significant results. In particular, all three have utilized cross-sectional data and have been hampered by the lack of variation of nominal Reserve pay in their sample.

The only time series study of reservist supply [18] reporting an estimate of the Reserve wage elasticity reached markedly different conclusions. This time series analysis was flawed, however, by its use of data contaminated by draft effects. Under a draft, only part of the return to Reserve service involves actual military pay. Most of the return lies in the civilian primary income, which is protected for reservists who do not have to forego their jobs for full-time military service.

Given the importance of the question of reservist supply response to national decisions about defense manpower policy, two potentially useful strategies are available for continuing the analysis of reservist supply behavior. One strategy simply continues the partial equilibrium analysis standard in the military manpower field by estimating equations similar to (1) and (2) with updated data. Reserve components have been offering enlistment bonuses to selected recruits since October 1979. These bonuses break the high correlation between Reserve pay and civilian pay which existed from 1973 to 1979. The addition of these new time series observations to prior Reserve manpower data bases may permit much more accurate estimation of the Reserve pay elasticity.

The second strategy requires modeling the entire Reserve personnel system. Although this approach is much more challenging, this larger model could:

- o Incorporate the social aspects of Reserve service into the analysis.
- o Examine the linkage between the functions performed by the individual unit and its ability to attract and retain personnel.
- o Analyze the interactions between the recruiting activities of individual Reserve units and between Reserve units and the Active Force.

The results reported here, although constrained by the aggregate nature of the data used, demonstrate the feasibility and potential utility of this expanded analysis. The collection of data on individual Reserve units would not only greatly enhance the precision of the estimates, but would also allow the demand section of the model to be considerably enriched.

Information about equipment levels, deployment dates, and actual missions would make the model much more useful to Reserve decisionmakers. It would also lay out more clearly the interrelationship between unit functions and personnel supply. Such phenomena as the relative attractiveness of headquarters units and the unattractiveness of combat units could be captured to improve both the demand and supply sections of the model.

I would suggest that both lines of research are worthy of pursuit. The first, although limited, is an easy, well-defined task. The second, which involves more conceptualization and a great deal more data collections, offers much more promise. Reserve personnel analysis would be more useful to decisionmakers if it could relate resource decisions to actual operational capabilities.



NOTES

1. Dorothy Amey, Alan Flechter, Daniel Huck, and Kenneth Midlam, Econometric Models of Armed Forces Enlistment Levels, General Research Corporation, October 1976, provide a useful summary of several studies showing the sensitivity of the supply of active force personnel to pay incentives.
2. Bernard Rostker, Air Reserve Personnel Study: Volume III Total Force Planning, Personnel Costs, and the Supply of New Reservists, The Rand Corporation, R-1430-PR, October 1974.
3. Robert Kelly, "The Supply of Volunteers to the Selected Reserve," United States Military Academy, Department of Social Services, May 1979 (mimeo).
4. William McNaught and Corazon Francisco, The Supply of Enlistees to the Selected Reserve Forces, The Rand Corporation, N-1562-MRAL, forthcoming.
5. Robert Shishko and Bernard Rostker, "The Economics of Multiple Job Holding," The American Economic Review, June 1976.
6. William McNaught, Projecting Future Accessions to the Selected Reserve Components, The Rand Corporation, N-1563-MRAL, August 1980.
7. Department of Defense, OSD(MRA&L), America's Volunteers: A Report on the All Volunteer Armed Force, December 1976.
8. During FY78 the National Guard and the Army Reserve tested a bonus for reenlistment. This test identified experimental and control groups of reservists who originally joined the Reserve directly from civilian life and were eligible for reenlistment during calendar 1978. In conjunction with this test, a comprehensive survey was administered to both the experimental and control groups. Analysis of this data, now under way at The Rand Corporation, will substantially increase our knowledge about the motivations towards Reserve retention.
9. An exception is David L. Jaquette and Gary R. Nelson, The Implications of Manpower Supply and Productivity for the Pay and Composition of the Military Force: An Optimization Model, The Rand Corporation, R-1451-ARPA, July 1974.
10. In one section of The Air Reserve Forces Personnel Study, Volume IV: Personnel Shortages and Combat Capability, F. S. Morgan, L. V. Sciffer, and O. K. Shelton estimate the isoquants of a Reserve production function defined for inputs of NPS and PS personnel. This is the only published study of the characteristics of Reserve labor productivity known to me.
11. For one discussion of this type of sociological approach to Reserve behavior, see Lowndes Stephens, "Recruiting and Retaining the Citizen-Soldier," Armed Forces and Society, November 1977.
12. Each recruit entering either the active or Reserve forces takes a mental aptitude test prior to entry. The services distinguish five categories of recruits based on the percentile scores of this test: (I) 93-100, (II) 65-92, (III) 31-64, (IV) 10-31, and (V) 0-9. Category V personnel are prohibited by law from entry. Category IV are generally regarded as less desirable by military recruiters.
13. Bureau of the Census, Current Population Reports, Money Income and Poverty Status in 1975 of Families and Persons in the United States by Divisions and States, Series P-60, pp. 110-113.

14. Income figures were adjusted from 1975 to 1977 by multiplying each value by the ratio of 1977 per capita income to 1975 per capita income average in each state. State price indexes were developed from data in the Bureau of Labor Statistics News, Fall 1977 Urban Family Budgets.
15. Bureau of Labor Statistics, Current Population Survey, Series P-20, Table 1, p. 334, January 1979.
16. Bureau of labor Statistics, Current Population Survey, Employment and Earnings, April 1977 through March 1978, Tables C-13 and E-1.
17. Arnold Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias," Journal of the American Statistical Association, 1962.
18. Kostker's (see Note 2) data base pooled time series and cross-sectional observations.

