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RESEARCH MEMORANDUM

A TECHNIQUE FOR ESTIMATING THE EFFECT OF PAY ON SELECTED RESERVE SUPPLY

Beth J. Asch

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**A TECHNIQUE FOR
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OF PAY ON
SELECTED RESERVE SUPPLY**

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INTRODUCTION

The size of the Selected Reserve (SELRES) force has been increasing in the last 3 years and is programmed to increase even more in the future. This growth is the result of pressure from Congress to more fully utilize the Reserve force as a means of reducing defense costs. An important problem the Navy faces is finding cost-effective ways of achieving its programmed growth. Future growth goals may be difficult to achieve because the Naval Reserve is primarily manned by Navy veterans who are volunteers rather than obligors of the Reserves.

Two policies for achieving Reserve manning goals are increasing Reserve pay and increasing recruiting effort. This paper discusses methods of estimating the effect of these policies on enlisted Reserve supply. In the process, issues that are unique to the Reserve supply problem are discussed in detail and incorporated into the estimation model.

RESERVE GROWTH ENVIRONMENT: PAST, PRESENT, AND FUTURE

Selected reservists are civilians who drill 1 weekend a month and 2 weeks a year.¹ Historically, most Selected Reservists have been Navy veterans (NAVETs). Recently, however, the Naval Reserve has recruited individuals with no prior military experience under the Sea and Air Mariner (SAM) program.² Most reservists are recruited within 100 miles of the drill site because individuals who travel farther must be reimbursed for lodging. The supply model, therefore, must be geographic specific.

Since the Reserves are a part-time force, Reserve units have lower personnel costs than comparable active-duty units. Ships in the Reserves therefore operate less per quarter and, as a result, have lower fuel costs and possibly lower maintenance costs than ships in the active force. These savings are the primary advantage of placing units in the Reserves.

Because of the savings, Congress has tied future increases in the size of the active force to greater utilization of the Reserves. This Congressional pressure is particularly great on the Navy because in the next few years, the programmed 600 ships will require additional active-duty endstrength. The Navy is also the least Reserve intensive of all

-
1. The Selected Reserve is one component of the Ready Reserve. The other component is the Individual Ready Reserve (IRR). Individuals in the IRR have no drilling obligation.
 2. Sea and Air Mariners are untrained recruits who have an 8-year obligation to the Navy. After completing boot camp and schooling, which takes 6 to 18 months, these individuals are Selected Reservists for the duration of their military obligation.

the services. Table 1 shows projections of how Reserve-intensive (defined as the percent of total endstrength that is reservist) the Army, Air Force, and Navy are in FY 1985 and will be in FY 1990. In FY 1985, the Army's use of reservists is projected to be nearly three times as large as the Navy's. This differential declines by FY 1990, but even then the use of reservists by the Army is more than twice that of the Navy's.

TABLE 1
RESERVE COMPONENT AS A PERCENTAGE OF TOTAL ENDSTRENGTH

	<u>FY 1985</u>	<u>FY 1990</u>
Army	48	52
Air Force	23	24
Navy	18	21

The Navy has responded to this Congressional pressure by programming a dramatic increase in SELRES, as table 2 shows. In FY 1991, SELRES will be over 50 percent larger than in FY 1980. This increase breaks from past trends; prior to FY 1983, the size of SELRES was fairly stable.

TABLE 2
NUMBER OF NAVAL SELECTED RESERVISTS
FY 1980 - FY 1991

<u>Year</u>	<u>Drilling Reservists</u>
1980	70,000
1981	71,000
1982	74,000
1983	86,000
1984	93,000
1985	96,000
1986	98,000
1987	102,000
1988	103,000
1989	105,000
1990	106,000
1991	107,000

The most visible area of SELRES growth is in the Naval Reserve Force (NRF). Table 3 shows the programmed additions to the NRF from FY 1985 through FY 1991. By FY 1991, 76 additional ships will be in the Reserves. This represents a significant increase in the NRF because 18 (the MSO-class minesweepers) of the 36 ships currently in the NRF will be decommissioned by FY 1991. The different NRF ships represent a wide variety of manpower requirements. The mine warfare ships are small and require a junior force, whereas the frigates and underway replenishment ships require a more highly trained and senior force.

TABLE 3
PROGRAMMED ADDITIONS TO THE NAVAL RESERVE FORCE
FY 1985 - FY 1991

<u>Ship Type</u>	<u>Ship Count</u>
Frigates	
FFG-7	15
FF-1052	2
Landing craft carriers	
LST	1
LSD	1
Mine warfare ships	
MCM	14
MSH	14
COOP	22
Fleet support ships	
ARS	2
Underway replenishment ships	
AO	<u>5</u>
Total	76

POLICIES FOR MEETING FUTURE MANPOWER REQUIREMENTS

Given the large programmed increase in SELRES and, in particular, in the NRF, the Navy must find cost-effective ways of achieving its growth goal and of targeting that growth toward potential NRF homeports. A second problem involves locating enough personnel with the right skills to man the Reserve ships. Since reservists are civilians, ships must be homeported where the people are located. Difficulties arise, however, when the Navy tries to match ships to locations. Each ship requires a different set of occupations or ratings, and each location has a different distribution of NAVETs across ratings. Also, NAVETs affiliate with the Reserves with different probabilities.

Past CNA analysis [1] shows that if the Navy continues its policies regarding recruiting and pay, an insufficient number of Navy veterans will affiliate with the Reserves to meet future SELRES requirements in all of the traditional homeports. Figure 1 illustrates the comparisons of estimated NAVET supply with future requirements for several of the planned NRF homeports: Newport and Boston, Philadelphia and New York, Norfolk, Charleston, and Mayport. The supply estimates in figure 1 reflect past Navy policies regarding recruiting and pay since they are based on data from FY 1980 through FY 1984. As table 2 shows, this period was one of slow growth for SELRES. Therefore, if the Navy is to achieve its growth goals, other policies must be considered since continuing past policies will not induce enough supply to meet future requirements.

One policy tool available is changing the active/Reserve crew mix of the NRF ships. Currently, 60 percent of the crew are on active duty and 40 percent are in the Selected Reserve. The Navy could change this split, subject to Congressional approval, to increase the percentages of active duty personnel in the NRF crew. Another policy is changing the type of ships placed into the NRF. Since each ship requires a different rating mix, the Navy could place ships into the NRF that are more compatible with the available supply of ratings in the Reserves. Another policy is a "fly-in" program. Under this policy, individuals from locations farther than 100 miles would be flown to the drill site to man hard-to-fill ship billets.

Additional policies are increasing recruiting efforts, such as the number of recruiters and advertising expenditures, and increasing Reserve compensation, such as pay and bonuses, to reflect geographic differences in supply. This study focuses on the last policy by examining techniques to estimate the effect of an increase in Reserve compensation on Reserve affiliation. The effect of an increase in recruiting effort can be estimated using the techniques described below. However, due to a lack of data on advertising and the number of recruiters, this policy variable is not included at this stage of the analysis.

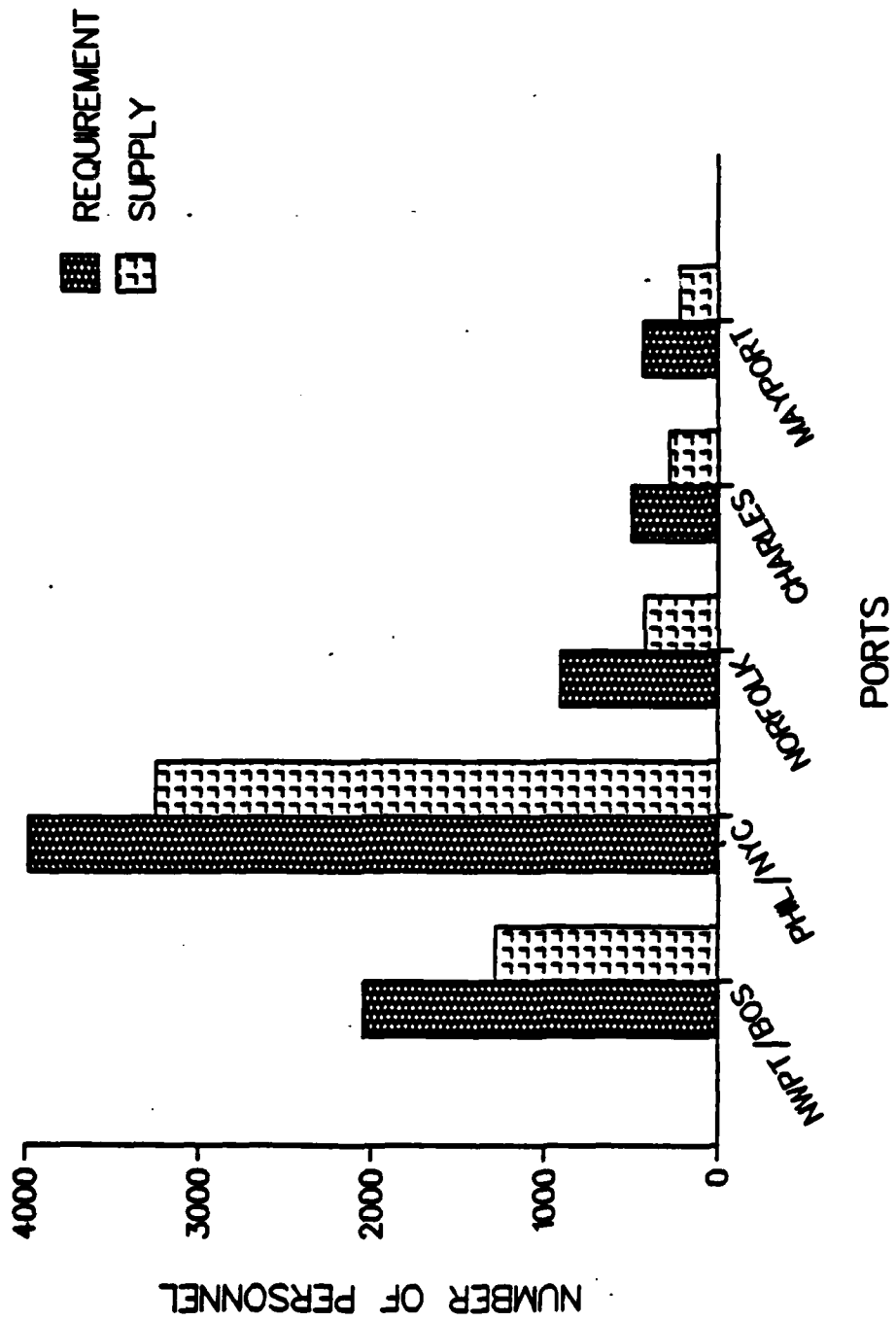


FIG. 1: SELRES REQUIREMENTS VS. NAVET SUPPLY OF RESERVISTS

ESTIMATION ISSUES

Previous Supply Estimates

Estimating the effect of pay on affiliations involves estimating a supply curve and using the estimated coefficient on pay to construct the pay elasticity. The pay elasticity tells the percentage of change in supply that results from a 1-percent change in pay, holding everything else constant. Previous studies on military enlistments have estimated supply curves. Most, however, were for individuals enlisting to active duty and not to the Reserves. Two exceptions are a study on Naval Reserve enlistments by Quester [2] and a study on Reserve enlistments for all of the services by McNaught[3].

The Quester study estimates the elasticity of NAVET accessions with respect to Reserve pay, by rating for individuals in paygrades E4 to E6 using national data. The average Reserve pay elasticity was 1.56, assuming a 10.5-percent unemployment rate. McNaught estimates the Reserve pay elasticities for individuals with and without prior military experience for each service using national data. For individuals with prior Navy experience, he estimates a Reserve pay elasticity of 1.44. McNaught also finds statistically significant regional dummies, indicating that including geographic variations in the analysis is important.

Unfortunately, neither of these studies provides elasticity estimates that can be used by the Navy to determine whether changing pay is a viable policy option for meeting future SELRES requirements. Both studies use national rather than geographic-specific data. The Quester study uses data on individuals only in paygrades E4 to E6 rather than in all the paygrades. The McNaught study estimates supply by aggregating all of the ratings together rather than estimating supply curves for each one individually. Finally, both studies ignore the existence of demand constraints, which, if ignored, will bias estimates of supply. Since this issue is important for this analysis, it is discussed in detail below.

Demand Constraints

A demand-constrained environment refers to a situation where, at the going level of compensation, supply exceeds demand. Demand constraints are a special case of equilibrium constraints, illustrated in figure 2. At a higher-than-equilibrium pay level, supply exceeds demand and enlistments are demand constrained. At a lower-than-equilibrium pay level, demand exceeds supply and enlistments are supply constrained. Observed enlistments are therefore the minimum of demand and supply.

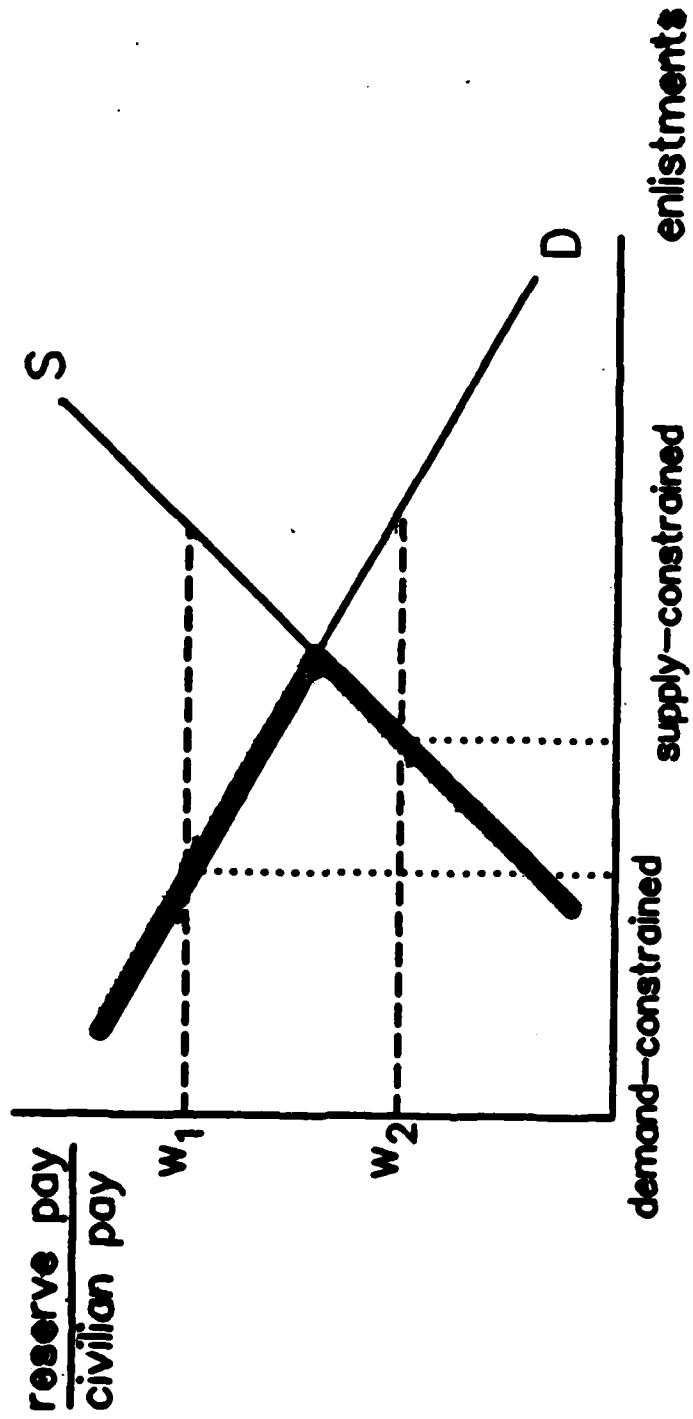


FIG. 2: EQUILIBRIUM CONSTRAINTS

Demand constraints are relevant to this analysis because the projections of future supply are based on past enlistments. The recent past, as table 2 shows, for the period FY 1980 through FY 1984, was a period of stagnant growth. The near future, on the other hand, will be a period of enormous growth. Using enlistments that occurred in the past (when supply was demand constrained) to project future enlistments (when supply will be unconstrained) will produce biased estimates if the demand constraints are not accounted for. Therefore, this analysis examines demand constraints relevant to Reserve supply to ensure that the estimates of future supply are unbiased.

The cause of the bias is illustrated in figure 3. If some observations lie along the demand curve and some along the supply curve, then the estimated regression line will lie between these curves. The slope of the true supply curve will therefore be underestimated. To correctly estimate the elasticity of supply with respect to pay, demand-constrained and supply-constrained observations must be distinguished.

At the national level, demand-constrained enlistments into the Reserves occur because of a policy of low overall growth. Demand-constrained enlistments also occur at the local level. Certain areas have not, historically, been NRF homeports. As a result, the demand for reservists in these areas has been limited. However, if the low level of enlistments is attributed to the lack of desire to join the Reserves rather than to the limited demand, then future supply of reservists will be underestimated in these locations.

Three types of demand constraints particularly affect Reserve accessions: local billet constraints; restricted entry into certain occupations; and recruiter goals. Local billet constraints are discussed earlier; if an area has not been a traditional Navy homeport, then historically the area has had limited demand relative to supply. Restrictions on entry into certain occupations are part of the Reserve Recruiting and Manning Objectives System (RAMOS) and, because of their importance, are discussed in detail below. Recruiter goals are another source of demand-constrained enlistments. These goals are set by the Navy as means of achieving its endstrength goals. Recruiter goals have been shown to influence active-duty enlistments [4]. This may not be true, however, for Reserve enlistments. According to the Commander, Naval Reserve Force (COMNAVRESFOR), recruiting section, recruiter goals are set unrealistically high, implying that the goals are not a constraint. Unfortunately, due to lack of data on recruiter goals, verification of this is not possible. In the following analysis, demand constraints resulting from recruiter goals are therefore ignored.

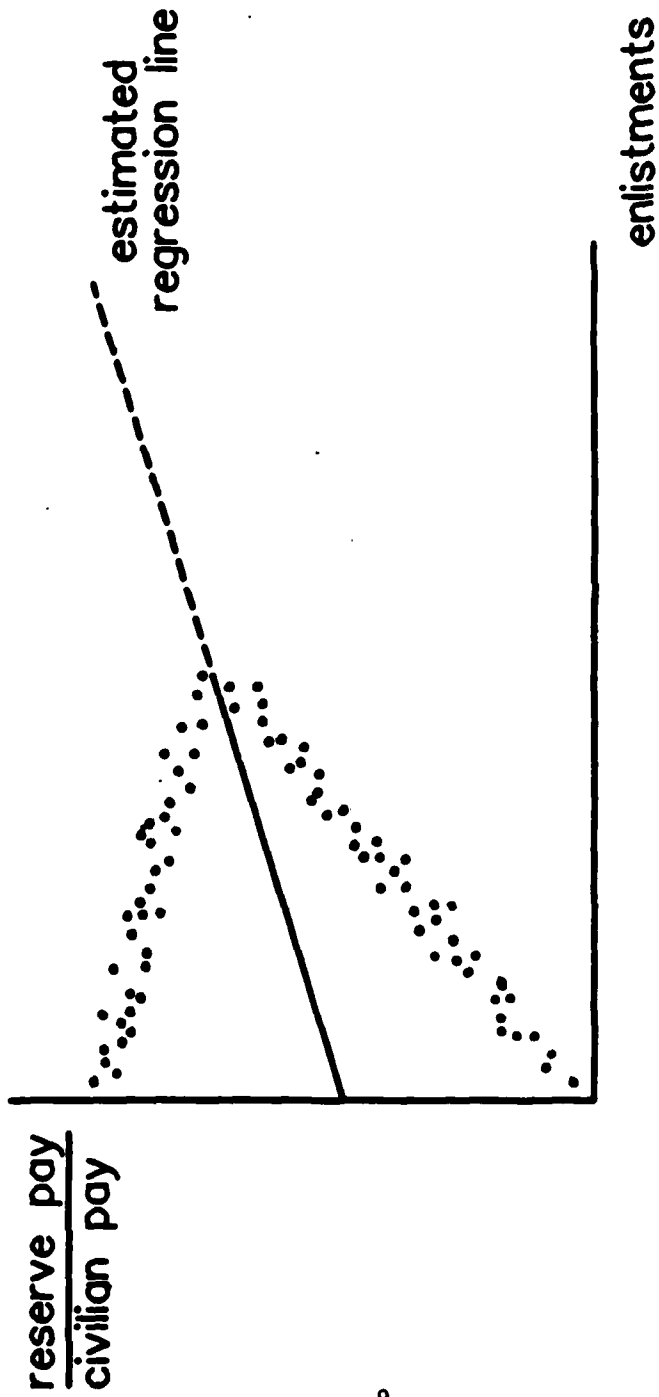


FIG. 3: ESTIMATED SUPPLY FUNCTION WHEN SOME OBSERVATIONS ARE CONSTRAINED BY DEMAND

Open and Closed Occupations (RAMOS)

Historically, certain ratings or occupations have been overmanned and certain ratings have been undermanned relative to requirements.¹ To correct this problem, the Navy developed RAMOS to identify and control the recruiting of individuals in these ratings. Each quarter, the Navy uses national data to compare the number of billets available in each rating to the number filled. Ratings are then placed into RAMOS categories based on the degree of oversupply or shortage. Ratings less than 80-percent manned are in group A; ratings 80- to 89-percent manned are in group B; ratings 90- to 100-percent manned are in group C; ratings 101- to 110-percent manned are in group D; and ratings over 110-percent manned are in group E.

RAMOS provides guidelines to the recruiters on which ratings to recruit in a given quarter. When a rating is in category A, B, or C, the recruiter can recruit new individuals into the rating. When the rating is in group D or E, however, the recruiter cannot recruit new individuals unless he or she has the permission of COMNAVRESFOR.

Since RAMOS is based on national data, it is possible that its recruiting guidelines will conflict with the availability of billets at the local level. Figure 4 illustrates how this can occur. Local billet availability is listed along the top of the table, vacant or not vacant, and RAMOS groups A, B, C or D, E are listed along the side. When RAMOS is A, B, or C, meaning that there is a shortage in the rating nationally, and some billets are vacant in a given location, then the RAMOS group and the local billet situation are consistent; individuals are recruited to fill the vacancies. Similarly, when RAMOS is D or E and no local billets are vacant, then RAMOS and local billet availability both require that the recruiter does not recruit individuals in that rating. RAMOS and local billet availability, however, may be inconsistent. RAMOS can be A, B, or C when local billets are not available, or RAMOS can be D or E when local billets are available.

When RAMOS and local billet availability conflict, RAMOS turns out to be the binding constraint. The Navy recruits individuals if the rating is RAMOS group A, B, or C even when local billets are not available; the Navy does not recruit if RAMOS is D or E even when local billets are available. This is possible because recruiters can cross-assign individuals. Cross-assignment means that the recruiter recruits individuals in an area that has no vacant billets and assigns them to another area that does. The individuals train with the local unit but mobilize with the out-of-town unit. When RAMOS is A, B, or C and no

1. This study only examines RAMOS categories for ratings and not for paygrades since rating substitution is more difficult than paygrade substitution.

LOCAL BILLET AVAILABILITY

		vacant	none vacant
RAMOS	A, B, C	recruit	recruit
	D, E	don't recruit	don't recruit

FIG. 4: RECRUITING DECISION RULES

local billets are vacant, the recruiter will cross-assign individuals to other areas. When RAMOS is D or E, the recruiter reassigns the cross-assigned individual back to the local area rather than recruiting someone new. This means that the individual not only drills but also mobilizes with the local unit. However, when no one is available to reassign back to the local area, the recruiter can get authorization from COMNAVRESFOR to recruit a new individual to fill the vacancy. As a result, a few individuals will be recruited even when RAMOS is D or E.

Since RAMOS usually prevails despite the local billet situation, the number of observed enlistments in a given rating will be determined by its RAMOS category. Observed enlistments for each rating will therefore fall into one of three cases given that the data used is a time series of enlistments by geographic area. These cases are illustrated in figures 5 through 7. These figures were created to illustrate the cases clearly and do not illustrate actual observations on enlistments.

In case 1, all the enlistments for a given rating are observed during periods when RAMOS is A, B, or C. In other words, none of the observations are demand constrained. As figure 5 shows, the observations will trace out a supply curve. In this case, the estimation of the pay elasticity simply requires estimating the supply function for the rating and using the slope coefficient on pay to calculate the pay elasticity.

In case 2, all of the enlistments for a given rating are observed during periods when RAMOS is D or E. In this case, all of the observations are demand constrained. Figure 6 shows that the observations trace out a vertical line centered near but not at zero, since a few enlistments occur even when RAMOS is D or E. Under case 2, the pay elasticity is derived using the estimated parameters of the supply function in case 1 (the unconstrained case) to predict the demand-constrained behavior in case 2.

In case 3, some enlistments occur in periods when RAMOS is A, B, or C, and some enlistments occur in periods when RAMOS is D or E. Here, some observations are demand constrained and some are not. Figure 7 shows that the enlistments that occur when RAMOS is A, B, or C trace out a supply function, and the enlistments that occur when RAMOS is D or E trace out a vertical line centered near zero. Using all of the observations to estimate a supply function would produce a biased estimate of the pay elasticity because some of the observations are demand constrained. An unbiased pay elasticity can be estimated by throwing out the enlistments observed when RAMOS is D or E and estimating the supply function using the unconstrained observations.

reserve pay
civilian pay



enlistments

FIG. 5: CASE 1: RANOS = A, B, OR C

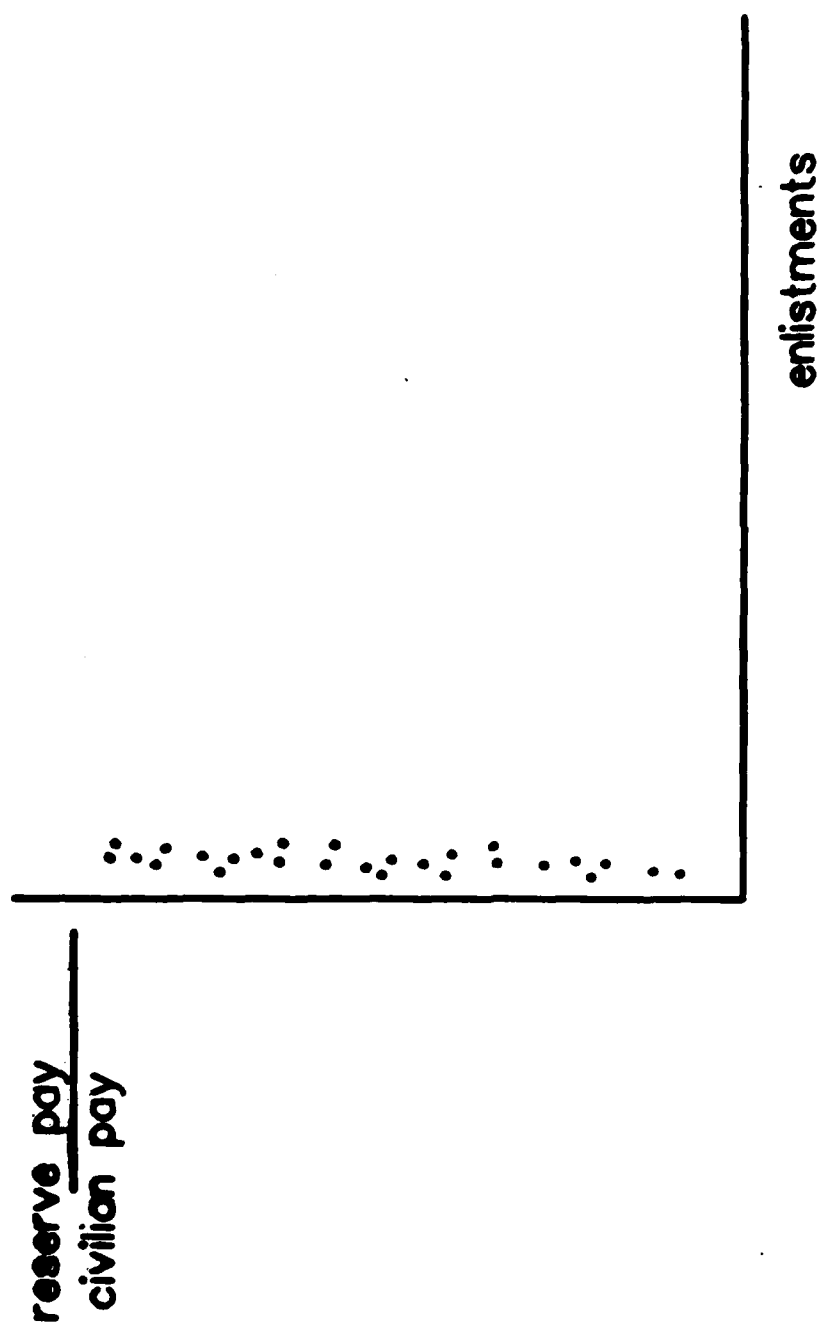


FIG. 6: CASE 2: RANOS - D OR E

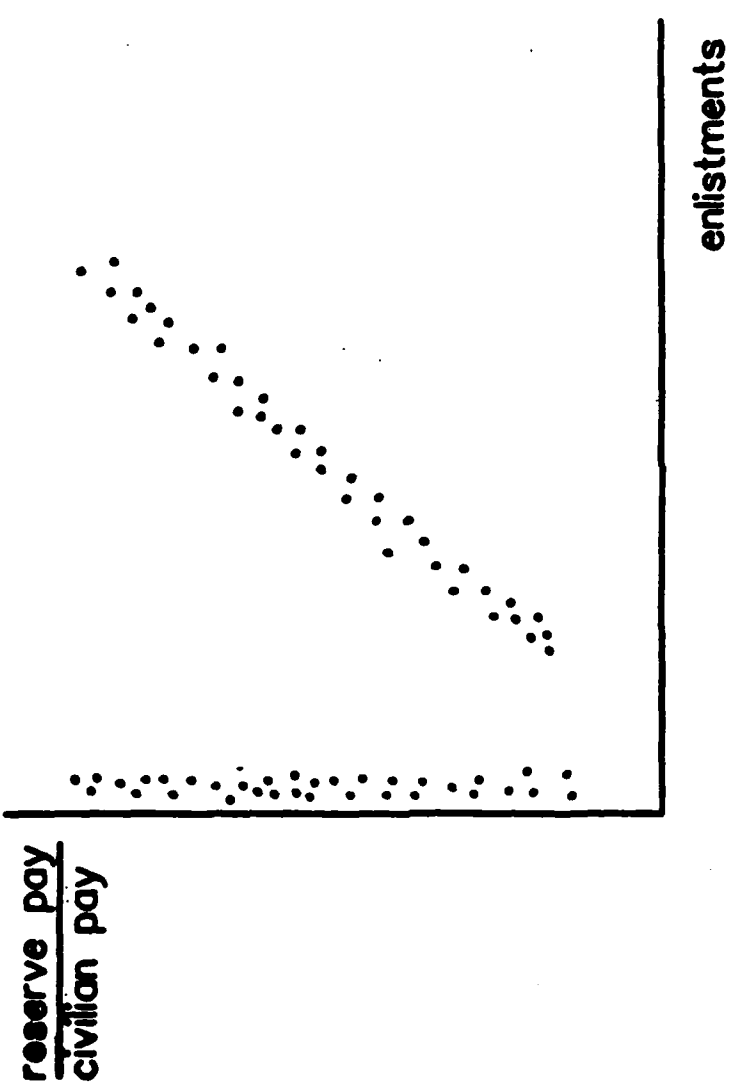


FIG. 7: CASE 3: RAMOS = A, B, C OR D, E

ESTIMATION TECHNIQUES

The technique outlined above, in a more general framework, is a switching regression model with an exogenous switching rule. The switching rule is exogenous because each local area that is a potential homeport takes RAMOS, which is determined nationally, as given. The switching model is:

$$Y = \beta X + \epsilon, \quad (\text{if RAMOS} = A, B, C) \quad (1a)$$

$$Y = 0, \quad (\text{if RAMOS} = D, E) \quad (1b)$$

where Y is the Reserve affiliation variable for each rating in each location and X is a vector of explanatory variables, including Reserve pay; individual-specific variables such as education, AFQT score, marital status, and race; location-specific variables such as the local unemployment rate; and Navy-specific variables such as the size of the Navy establishment in the location.

This model is a switching model because when RAMOS is A, B, or C, equation 1a prevails, whereas when RAMOS is D or E, equation 1b prevails. The parameter estimates of equation 1a are used to predict the pay elasticity for the constrained enlistments of equation 1b. When RAMOS is A, B, C or D, E, equation 1a prevails for some observations and equation 1b prevails for others. To obtain unbiased estimates of the pay elasticity in this case, equation 1a is estimated using only the enlistments observed when RAMOS is group A, B, or C.

The data to be used in this analysis are pooled cross-section time-series. Monthly data on individuals leaving the Navy by rating from FY 1980 through FY 1983, obtained from the Defense Manpower Data Center's (DMDC's) retention file, are used. These data are matched by Social Security number with SELRES monthly affiliation data by rating for FY 1980 through FY 1984, obtained from the Reserve Components Common Personnel Data System (RCCPDS), to ascertain which Navy veterans affiliated with the Reserves after leaving active duty. The DMDC data source has a zipcode field that tells where in the country the Navy veteran anticipates he or she will live. This analysis focuses on 14 Navy homeports because one of the purposes of this study is to estimate the supply of reservists by geographic location to man NRF ships. These ports are: Charleston, Galveston, Long Beach, New York, Philadelphia, Portland (Oregon), San Diego, San Francisco, Seattle, Pearl Harbor, Newport, Mayport, Norfolk, and Boston. The data set therefore has the following information by rating on each Navy veteran who left active duty between FY 1980 and FY 1983: the NAVET's residence; whether or not the NAVET affiliated with the Reserves, and if so, when; the RAMOS

categories of the NAVET's rating; and the NAVET's personal characteristics, such as race, gender, marital status, and education.

Logit Model

The supply model, equation 1a, can be estimated using maximum likelihood techniques. To derive the likelihood function, let I_i^* be an index variable that models a NAVET's decision process. I_i^* is given by:

$$I_i^* = \beta_{rj} X_i - \epsilon_i \quad , \quad (2)$$

where i is the individual, r is the rating, and j is the location. The higher is I_i^* the more likely a NAVET will affiliate with the Reserves. Generally, I_i^* is unobservable. However, what is observed is the event of whether or not a NAVET affiliates. Let I_i be an observable index such that:

$$\begin{aligned} I_i = 1 & \quad \text{if } I_i^* > 0, & \quad \text{NAVET affiliates;} \\ I_i = 0 & \quad \text{otherwise,} & \quad \text{NAVET does not affiliate.} \end{aligned} \quad (3)$$

If P_i is defined as the probability that a NAVET affiliates and P_i is assumed to come from a logit distribution, then:

$$\begin{aligned} P_i &= \Pr(I_i = 1) = \Pr(I_i^* > 0) \\ &= F(\beta_{rj} X_i) \\ &= \frac{1}{1 + \exp(-\beta_{rj} X_i)} \end{aligned} \quad (4)$$

The likelihood function is therefore:

$$L = \prod_{I_i=1} F(\beta_{rj} X_i) \prod_{I_i=0} [1 - F(\beta_{rj} X_i)] \quad . \quad (5)$$

Maximization of equation 5 will give parameter estimates of the β_{rj} 's. These estimates can then be used to construct pay elasticities.

Partially Unobserved Bivariate Probit Model

The switching regression technique estimates demand-constrained supply by using the parameter estimates of the unconstrained supply function. This technique implicitly assumes, however, that the uncon-

strained and constrained supply functions are identical; the only difference being the demand environment in which enlistments occur. This assumption may not be true. Some ratings are eligible for Selected Reenlistment Bonuses (SRBs), which are bonuses that the Navy gives to encourage reenlistments to active duty. Therefore, individuals in these ratings are less likely to join the Reserves and more likely to be in ratings that are RAMOS A, B, or C. As a result, different variables, such as SRB levels, will influence the supply of these individuals. Estimating separate supply functions for individuals in ratings that are RAMOS A, B, C--versus D or E--will therefore be more appropriate.

A few enlistments occur even when RAMOS is group D or E because there are no cross-assigned individuals who can be reassigned back to the local drill site. These enlistments can be used, if enough exist, to estimate the supply function. However, the estimation technique is not straightforward because one must infer from the constrained enlistments the supply characteristics had they been unconstrained. A technique to do this, developed by Poirer [5], is the partially unobserved bivariate probit method.

Under Poirer's framework, affiliations are considered to be a function of two decisions: the Navy's decision to recruit new reservists and the NAVET's decision to join the Reserves. Only the joint decision of the Navy and the NAVET are observed, however; if both decide positively, then an affiliation is observed. If no affiliation is observed, it could mean one of three things: The Navy wanted to recruit but the NAVET did not want to join the Reserves; the NAVET wanted to join but the Navy did not want to recruit the reservist; or both the Navy did not want to recruit and NAVET did not want to join the Reserves. This framework effectively models affiliations that occur when RAMOS is D or E because when affiliations are demand constrained, both decisionmakers determine whether an enlistment occurs.

Estimating the supply function requires inferring the separate decisions of the NAVET and the Navy from their joint decision. This is only possible if some variables influence the Navy's decision but do not influence the NAVET's and vice versa. Obviously, a sufficient number of observations in the demand-constrained environment must exist to allow estimation of supply.

Let I_1^* and I_2^* be unobserved utility indices for the NAVET and Navy, respectively.¹ I_1^* determines whether or not the NAVET joins the Reserves, and I_2^* determines whether or not the Navy recruits reservists. I_1^* and I_2^* are assumed to be given by:

1. The subscripts i, r, and j are dropped here for simplicity of notation.

$$I_1^* = X_1\beta_1 - \epsilon_1, \quad (\text{NAVET})$$

$$I_2^* = X_2\beta_2 - \epsilon_2, \quad (\text{Navy}) \quad (6)$$

assuming $E(\epsilon_1) = E(\epsilon_2) = 0$, and $\text{Var}(\epsilon_1) = \text{Var}(\epsilon_2) = 1$.

Define I_1 and I_2 as:

$$\begin{aligned} I_1 &= 1 && \text{If } I_1^* > 0, && \text{NAVET wants to join Reserves;} \\ I_1 &= 0 && \text{otherwise,} && \text{NAVET does not want to join} \\ &&& && \text{Reserves.} \end{aligned} \quad (7)$$

$$\begin{aligned} I_2 &= 1 && \text{If } I_2^* > 0, && \text{Navy recruits reservist;} \\ I_2 &= 0 && \text{otherwise,} && \text{Navy does not recruit} \\ &&& && \text{reservist.} \end{aligned} \quad (8)$$

The probability that a NAVET decides to join the Reserves and the probability that the Navy decides to recruit reservists are therefore given by:

$$\begin{aligned} \Pr(I_1 = 1) &= \Pr(I_1^* > 0) = \Pr(\epsilon_1 < X_1\beta_1) ; \\ \Pr(I_2 = 1) &= \Pr(I_2^* > 0) = \Pr(\epsilon_2 < X_2\beta_2) . \end{aligned} \quad (9)$$

Neither I_1 or I_2 are observed. Only the joint decision,

$I = I_1 \times I_2$, is observed with:

$$\begin{aligned} I &= 1. && (\text{Affiliate}) \\ I &= 0. && (\text{Do not affiliate}) \end{aligned} \quad (10)$$

The probability that a NAVET affiliates is therefore given by:

$$\begin{aligned} \Pr(I = 1) &= \Pr(I_1 = 1, I_2 = 1) = \Pr(I_1^* > 0, I_2^* > 0) \\ &= \Pr(\epsilon_1 < X_1\beta_1, \epsilon_2 < X_2\beta_2) \\ &= F(X_1\beta_1, X_2\beta_2, \rho) , \end{aligned} \quad (11)$$

where $F(X_1\beta_1, X_2\beta_2, \rho)$ is the joint CDF for ϵ_1 and ϵ_2 and can be assumed to be bivariate standard normal, and ρ is the covariance between ϵ_1 and ϵ_2 . The likelihood function is therefore:

$$\mathcal{L} = \prod_{I=1} F(X_1\beta_1, X_2\beta_2, \rho) \prod_{I=0} [1 - F(X_1\beta_1, X_2\beta_2, \rho)] . \quad (12)$$

The likelihood function is maximized to obtain parameter estimates for b_1 , b_2 and p . These estimates will be inefficient compared to those found when all choices are fully observed because less information is available. Also, they are only identified if there is at least one nonoverlapping variable in X_1 and X_2 . In other words, at least one variable must affect the Navy's decision which does not affect the NAVET's and vice versa.

One such variable is the local turnover rate. The Navy is more likely to recruit when turnover rates from Reserve units are high than when they are low, but local turnover rates probably have little effect on a NAVET's decision to join or not join the Reserves. Other variables are Reserve pay and the marital status and number of dependents a NAVET has. Reserve pay will affect a NAVET's decision to join the Reserves, but Reserve pay does not determine the number of reservists to be recruited at the local level. Rather, the number of vacant billets determines recruitments at the local level. Only nationally, from a policymaker's viewpoint, does Reserve pay influence how many reservists will be recruited. The NAVET who is married or has many dependents is more likely to take a second job or join the Reserves than a NAVET who is single or has no dependents. However, from the Navy's viewpoint, the NAVET's marital status or number of dependents is irrelevant for recruiting purposes.

SUMMARY

The purpose of this study is to provide estimates of the elasticity of Reserve affiliation with respect to pay by rating and geographic area. These estimates should provide some insight into the following questions:

1. How much does Reserve pay influence NAVET accession?
2. How much pay is necessary for supply to meet future SELRES demand?
3. Are geographic differences important?
4. Should the Navy target pay by geographic area?

The answers to these questions can help policymakers choose the most cost-effective way of achieving the Navy's programmed increase in its Selected Reserve force.

REFERENCES

- [1] CNA, Research Memorandum 85-73, "Manning the Naval Reserve Force," by Beth J. Asch, Unclassified, Oct 1985
- [2] CNA, Research Contribution 497, "Enlisted Accessions of Navy Veterans to the Selected Reserve," by Aline O. Quester, Unclassified, Aug 1983
- [3] Rand Corporation, Note N-1562-MRAL, "The Supply of Enlistees to the Selected Reserve Forces," by William McNaught, Unclassified, Jul 1981
- [4] Rand Corporation, Report R-3065-MIL, "Recruiter Incentives and Enlistment Supply," by James Dertourzos, Unclassified, May 1985
- [5] Poirer, Dale. "Partial Observability in Bivariate Probit Models." Journal of Econometrics, 12, No. 3 (Feb 1980)

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