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FOR
U.S. MILITARY LABOR

by

Kim ,Young Suk

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Thesis Advisor: Sohn, So Young

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The past year has been one of unprecedented change for the U.S. military organization. It would be of interest to analyze the impact of the changing situation on U. S. military labor demand. In this thesis, several demand models for U.S. military labor are considered to identify influential factors that predict the size of future military labor. A stepwise regression analysis is used to select some significant demand models. Data used to construct demand models in this thesis cover the period of 1963-1986 while actual data (1987-1990) are used to check model validity. Demand models selected are used to simulate force levels through the year 2000 under various scenarios.

Major contributions of this thesis are employing international security (war casualties), USSR's military end-strength and the past year's U. S. end strength in the prediction models for military labor demand. The resulting demand models turn out to be more parsimonious but they have better predictions than existing models. The results of simulation study based on various scenarios regarding war casualty and USSR's end strength would provide policy makers with useful information for future defense manpower plan.

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REGRESSION ANALYSIS OF DEMAND FOR U.S. MILITARY LABOR

by

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Submitted in partial fulfillment
of the requirements for the degree of

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ABSTRACT

The past year has been one of unprecedented change for the U.S. military organization. It would be of interest to analyze the impact of the changing situation on the U.S. military labor demand. In this thesis, several demand models for U.S. military labor are considered to identify those influential factors that best predict the size of the future military. A stepwise regression analysis is used to select some significant demand models. Data used to construct demand models in this thesis cover the period of 1963-1986, while actual data (1987-1990) are used to check model validity. Demand models selected are used to simulate force levels through the year 2000 under various scenarios.

Major contributions of this thesis are employing international security(war casualties), USSR's military end-strength and the past year's U.S. end-strength in the prediction models for military labor demand. The resulting demand models turn out to be more parsimonious but they provide better predictions than the existing model. The results of simulations based on various scenarios regarding war casualties and USSR's end-strength will provide policy makers with useful information for the future defense manpower plan.

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I. INTRODUCTION

A. BACKGROUND

The past year has been one of unprecedented change for the U.S. military organization. The destruction of the Berlin wall and the disintegration of the Warsaw Pact find the U.S. armed forces in a significantly different posture than it was a year ago. In light of changes in the current world political situations, one can expect corresponding alterations in the magnitude and structure of the defense budget. A major impact of reduced international political tensions may be a reduction of U.S. military labor demand. Under such circumstances, it is of interest to analyze the impact of the changing situations on U.S. military labor demand. In view of the extensive budget allocated for defense manpower, the necessity of an accurate forecasting model for military labor demand cannot be overemphasized. However, most military manpower research(Fisher [Ref 1], Ash, et al [Ref 2], Brown [Ref 3]) has focused on the determinants of the supply of military labor, especially on the impact of various forms of military compensation and the business cycle on enlistment. Only one major study, Deboer and Brorsen [Ref 4] has been done on the demand side of the military labor market. Frequently, labor demand has been implicitly treated as exogenous.

As a part of an econometrics model, Deboer and Brorsen [Ref 4] recently proposed a demand model as a function of military pay, the rental price of military equipment and structures, civilian government pay, GNP, Vietnam war casualties, and dummy variables representing the presidential administrations. In view of the large number of variables considered in their model, multicorrlinearity among predictors, as indicated by authors, caused difficulties in interpreting regression parameters. In addition, there are several factors that their demand model did not take into account: the changing international political situations, such as disintegration of Warsaw pact, and the previous years' U.S. military labor demand.

B. OBJECTIVE

In this thesis, we attempt to find parsimonious military labor demand models that include not only domestic changes but also changes in international security. The proposed demand models can, in turn, be used as a basis for the econometrics model that has been developed previously by Deboer and Brorsen [Ref 4].

We expect to use the resulting model to identify influential factors on military labor demand for the United States and to simulate force levels through the year 2000 under various scenarios regarding the selected predictors. These results will provide policy makers with useful information regarding the future plan for defense manpower.

C. THE SCOPE OF THESIS

The following gives the outline of the rest of the thesis. A brief literature survey on military labor models is provided along with Deboer and Brorsen's model [Ref 4] in Chapter II. In Chapter III, several candidate predictors are introduced to fomulate demand models for military labor. In addition, models are selected based on the stepwise regression analysis and compared to Deboer and Brorsen's model [Ref 4]. Based on the selected models, simulation studies are performed to predict the future demand for military labor in Chapter IV. Finally, in Chapter V, a summary of the results is given and the areas of further research are outlined.

II. LITERATURE REVIEW

First, general studies related to military manpower models are briefly reviewed in section A. In section B, details regarding Deboer and Brorsen's model [Ref 4] that motivated this study are summarized.

A. MILITARY MANPOWER MODELS

By and large, military manpower models in the literature can be classified into either supply models or demand models. There have been numerous investigations that have focused on finding influential factors that might induce the supply of military labor. Such studies include factor analysis of job satisfaction [Ref 11], recruitment [Ref 12] and reenlistment [Ref 13]. Many of these studies have used the following surveys conducted by the Defense Manpower Data Center (DMDC) [Ref 14]:

1. The 1985 DOD survey of officer and enlisted personnel
   - a world-wide survey of approximately 132000 activeduty military members.
2. The 1985 DOD survey of military spouses
   - a survey of the spouses of all married members selected for the member survey.

Brief summaries of the previous work are as follows:

Using the DOD (Department of Defense) surveys, Manggolo [Ref 11] investigated the relationship between race and job satisfaction. Samples used were black, hispanic and white enlistees in all four branches of service. The results of bivariate analysis, factor analysis and regression analysis indicated that black enlistees' levels of job satisfaction were significantly lower than those of other races.

There was an effort by Sullivan [Ref 12] to analyze differences and similarities in reenlistment factors for prior active service (PS) and non-prior active service (NPS) reservists. Reenlistment factors examined were demographic factors, tenure, cognitive and affective orientation, family income, civilian work environment, and perceived alternative job opportunities. Sullivan [Ref 12] found that the qualitative aspects of the reserve job and the civilian employer's attitude towards reserve participation were important variables to both PS and NPS reservists. In addition, satisfaction with pay, problems associated with obtaining transportation to and from drill sites, the amount of time spent on reserve duties, and the length of time to promotion turned out to be important factors considered by the reservist in making the reenlistmentmt decision.

In a similar context, Lucas [Ref 12] examined influences on the enlistment and reenlistment decisions for linguists in the U.S. Army. Previous language experience, ethnicity, age, gender, and education level of the respondent were considered in his study.

The analysis attempted to determine the differences between the linguists surveyed and appropriate control groups. The result indicated that the three most prominent reasons given for enlisting were a chance to better one's self, to earn money for college, and to receive training in a skill. Results further indicate that monetary benefits such as the Army's new enlistment, specialty, increased reenlistment bonuses strongly influenced the soldier's reenlistment decision.

The studies mentioned above all used micro-level(individual) data to estimate their models. Several other authors(Fisher[Ref 1], Ash, Udis, McNown [Ref 2], and Brown[Ref 3]) used aggregate data to develop supply models of military labor using predictors such as GNP and population. In these models, it was assumed that an individual's decision to enlist depends on a comparison between the returns to enlistment and the returns to the best civilian alternative: The ratio of military to civilian expected income streams was positively related to enlistment.

In sum, The studies using micro-level data found that the opportunity for better training and the opportunity to fulfill self-esteem can be considered as important factors for the supply of military labor. The studies using aggregate-level data found that population (possibly by race), the percentage variation of real GNP, and the military-civilian pay ratio are important factors.

B. DEBOER AND BRORSEN'S MODEL

1. Demand Model

As we observed in the previous section, most of the research on military manpower has been focused on the supply side of military labor market. Less work has been done on the demand side of the military labor market, which has been treated implicitly as exogenous. If the DOD set personnel levels and enlistment goals based on purely military and strategy considerations, ignoring demand would make sense. But such is not a case.

In recent study, Deboer and Brorsen [Ref 4] considered the military manpower demand and supply models simultaneously. Deboer and Brorsen developed a system of equations representing military labor demand and supply for the United States over the 1955-86 period, and used the results to simulate force levels, enlistments and relative pay through the year 2000 under various economic assumptions.

Specifically, Deboer and Brorsen's study [Ref 4] looked at how military labor demand and supply were equilibrated during the draft era and how it was equilibrated during the all-volunteer system. Data for the U.S. armed forces 1955-86 [Ref 8] were used to obtain the size of the U.S. military. All variables were measured on a federal fiscal year basis July through June before 1976, October through September since then. All the financial data were adjusted by the 1982 fiscal year basis. Induction and re-enlistments for fiscal years 1960-86 were from various issues of U.S. Bureau of the Census Statistical Abstract of the U.S. [Ref 8].

Enlistments were defined as the sum of non-prior service male volunteers and voluntary reserve activations. Inductions included draftees and involuntary reserve activations. End-strength was based on the total active duty military personnel as of the end of each fiscal year.

In their demand model of end-strength, the following independent variables were used:

ES= D(MILPAY, EQUIP, STRUC, CIVPAY, GNP, WAR, KENJOHN, NIXFORD, CARTER, REAGAN)

Where

ES: end strength, the annual end-of-year level of active personnel in the armed forces, in thousands;

MILPAY: military pay divided by the GNP consumption deflator;

EQUIP : the rental price of military equipment divided by the GNP consumption deflator;

STRUC: the rental price of military structures divided by the GNP consumption deflator;

CIVPAY: civilian government pay divided by the GNP consumption deflator;

GNP: real per capita gross national product;

WAR: Vietnam war casualties, in thousands;

KENJOHN: a dummy variable for the Kennedy and Johnson administrations, fiscal years 1962-1969;

NIXFORD: a dummy variable for the Nixon and Ford administrations, fiscal years 1970-1977;

CARTER: a dummy variable for the Carter administration, fiscal years 1978-1981;

REAGAN: a dummy variable for the Reagan administration fiscal years 1982-1986;

Deboer and Brorsen [Ref 4] included dummy variables for four presidential administrations to test for significant variations in the taste for military labor in comparison to Eisenhower administration.

2. Supply Model

Deboer and Brorsen [Ref 4] specified two supply equations, one for enlistments and one for reenlistments. First, high-quality enlistment supply is

ENLIST3 = S(POP18, PAYRATIO, INPUT, GNPGAP, YEAR)

For the enlistment supply model, the number of 18 and 19 years old males was included as the population variable (POP 18) [Ref 7] since this group provided the bulk of first time enlistment to the military.

Military compensation included a wide variety of pay and benefits. Their study used basic pay plus entitlements for enlisted men, which included money pay and the value of non-pension benefits received by soldiers below officer rank. Civilian pay was measured using the average compensation for non-military full-time employees, available from the National Income and Product Accounts (NIPA).

Their study also treated the pay ratio (PAYRATIO) as exogenous in both the pre-1973 draft and post-1973 All-Volunteer Force periods. The annual number of draftees through fiscal year 1973 was included as an independent variable. The number of inductions (INDUC) [Ref 8] was included rather than the draft probability because the young male population was included as an independent variable. Inductions were endogenous during the draft years when the draft was used to equilibrate labor supply and demand. The authors found that several other studies had shown that the draft had a positive effect on enlistments, because it reduced expected civilian pay, or because volunteers were offered a greater choice of duty assignments than draftees.

In addition, the GNP gap (GNPGAP) [Ref 6] was used for the enlistment supply model since one issue of interest was the response of enlistments to the business cycle. The effect was positive for expansions above trend, negative for recessions below trend. Finally, a time trend (YEAR) was included to capture possible systematic changes in the taste for military service.

The reenlistment supply model considered by Deboer and Brorsen [Ref 4] is as follows:

RERATE: R(INDSEP, PAYRATIO, GNPGAP)

where

RERATE: The reenlistment rate, the proportion of soldiers eligible to reenlist (or separate) who reenlist;

INDSEP: The percentage of soldiers eligible to separate who were drafted;

PAYRATIO: The ratio of enlisted basic pay plus enlistments to civilian compensation per FTE;

GNPGAP: The percentage deviation of real GNP from trend.

Reenlistments were a second source of military labor supply. The supply of soldiers eligible to reenlist was the number who had reached the end of their terms of enlistment. Draftees were expected to be less likely to reenlist than those who first enlisted voluntarily, and a higher military-civilian pay ratio would induce more reenlistments. Perceived opportunities for civilian employment would also influence reenlistments, so the GNP gap was included as an explanatory variable.

Finally, an identity equation was used to complete the military labor model, relating military labor supply and the end-strength demand:

ES = ENLIST3 + ENLIST4 + (RERAT * SEPARATE) + STOCK

Where

ENLIST4: The number of male recruits scoring below AFQT level III;

SEPARATE: The number of soldiers who are eligible to separate, i.e., whose enlistment periods have expired;

STOCK: The number of soldiers not eligible to separate.

III. DEMAND MODELS FOR U.S. MILITARY LABOR

A. MODEL

In view of the considerable amount of budget allocated to military manpower and the consequences of under or over-estimating military labor demand, the importance of accurate predictions of end-strength demand cannot be overemphasized. However, as observed in the literature review, many studies have focused on the supply side of military labor. Recently Deboer and Brorsen [Ref 4], considered a demand equation explicitly modeled in conjunction with supply models in the econometric analysis. However, their demand model included relatively many predictors (Milpay, Equip, Struc, Civpay, GNP, WAR, KenJohn, NixFord, Carter, Reagan). Inclusion of many explanatory Hxariables often causes multi-collinearity. In such a case, the role of each predictor on military labor demand may not be clear. In addition, their demand model did not consider potentially important predictors such as USSR's end-strength and the past trend of U.S. end-strength.

In this chapter, an attempt is made to provide parsimonious prediction models that can explain the variations in the demand for U.S military labor. We first consider additional candidate predictors such as USSR'end-strength and the past U.S. end-strength to a set of variables used in Deboer and Brorsen's model. A stepwise reqression analysis is used to select influential predictors out of many candidate variables. Details regarding additional candidate predictors considered in this thesis are as follows:

First, in view of the relationship between U.S. and USSR, USSR's end-strength(USSRES) appears to be one of the important variables that cannot be neglected as one of the predictors for US military labor demand. This study established the following hypotheses regarding the relationship between USSR'S End-strength (USSRED) and U.S.'s End strength (ES):

Hypothesis 1 : As USSR's end-strength increases, the U.S.'s End-strength also increases in order to balance the power.

Hypothesis 2 : As USSR's end-strength increases, instead of balancing the power by increasing the size of the end-strength, U.S. would invest more money and effort on high-tech scientific armament, which may result in a decrease in End-strength within the limited defense budget.

Second, in many cases, past history can be a good indicator of the current situation. particularly, it takes time for a huge organization to be adapted to sudden changes. Alterations in the size of US military labor can be a good example. The past year's size of military labor(ES1) can be an influential predictor for the current military labor.

Third, a dummy variable(PARTY) can be used to distinguish the different viewpoints of bipartisan administration on the demand of military labor. A similar attempt was made in Deboer and Brorsen's study [Ref 4] by considering each dummy variable for each presidential administration. Using their approach, a more accurate analysis of the differences among different presidential administrations can be done. However, in order to predict demand for military labor in the future, one has to define each future administration in relation to five presidential administrations that were used in their model. Use of one dummy variable representing bipartisan administration can reduce this kind of difficulty in the prediction.

In addition to these new variables, variables that were used in Deboer and Brorsen's demand model were also considered as a set of candidate predictors for a demand model for US military labor. In sum, a set of candidate explanatory variables considered for a military labor demand model in this thesis is as follows:

ES: United States End-strength, in thousands;

USSRES: USSR's End-strength, in thousands;

PARTY: Dummy Variable

=0 if president is democrat;

=1 if president is republican;

ES1: previous year's End-strength for United States, in thousands;

MILPAY: military pay divided by the GNP consumption deflator;

EQUIP: the rental price of military structures divided by the GNP consumption deflator;

STRUC: the rental price of military structures divided by the GNP consumption deflator;

CIVPAY: civilian government pay divided by the GNP consumption deflator;

GNP: Per Capita Gross National Product in 1982 dollars;

WAR: War Casualties, in thousands.

B. DATA ANALYSIS

The data used for this thesis are based on the file that was provided by Professors Deboer and Brorsen. This file was originally edited using several different sources:

- U.S. armed forces 1955-1986 (ES,ES1)
- Various issues of U.S. Bureau of the Census (GNP)
- Statistical Abstract of the U.S. (MILPAY,CIVPAY)

Details regarding the derivation of each variable are as follows:

Total military pay (MILPAY) and civilian pay (CIVPAY) were derived from employee compensation by industry from the National Income and Product Accounts.

Military compensation (MILPAY) was divided by military full time equivalent employment to derive total military pay. Civilian pay (CIVPAY) was all non-military compensation divided by all non-military FTE employment. Compensation included wages and salaries and non-wage benefits.

Rental prices for military equipment (EQUIP) and structures (STRUC) were derived using r=(d+i)p, where r was the rental price, d was depreciation, i was the interest rate and p was procurement costs. Depreciation rates were calculated as a proportion of beginning year net stock of military equipment or structures. The government civilian pay factor price was compensation per FTE. Vietnam War casualties included soldiers killed, wounded or missing over the 1961-73 period.

Real Gross National Product was obtained from the NIPA (National Income and Product Accounts) and U.S. population from the Statistical Abstract. All data were measured on a federal fiscal year basis and all the financial data were adjusted by '82 fiscal year basis.

The data for USSR's military end-strength (USSRES) 1963-1986 were obtained from The Military Balance by IISS(The International Institute for Strategic Studies) [Ref 9]. Since data for USSRES was not available prior to 1963, in this thesis the time period between 1963 and 1986 was used for selecting and estimating prediction models of demand for military labor.

Before a stepwise regression analysis was used, several pairs of ES and candidate predictors were plotted in order to explore the relationship between these variables.

First of all, Figure 1 shows the trend of ES and USSRES by year. It indicated that both U.S. and USSR increased their end-strength during the war time.

Observations based on Figure 2 suggest the inclusion of the higher degree polynomials of USSRES such as $USSRES^2$ and $USSRES^3$. It also indicates that the relationship between ES and USSRES is not simply linear, which implies that Hyphotheses 1 and 2 can be accepted depending upon the range of USSRES.

Figure 3 shows that a linear relationship between ES & ES1 prevails. As shown in Figure 4, the relationship between the ES and PARTY during 1963-1986 shows that the Democratic administration was in favor of larger military forces than the Republican administration in terms of average size of military labor. This result might be due to the fact that the Vietnam war occurred during Democratic administrations. An interesting feature appears in Figure 5, which indicates the ES as a function of square of war with degree of 0.5.

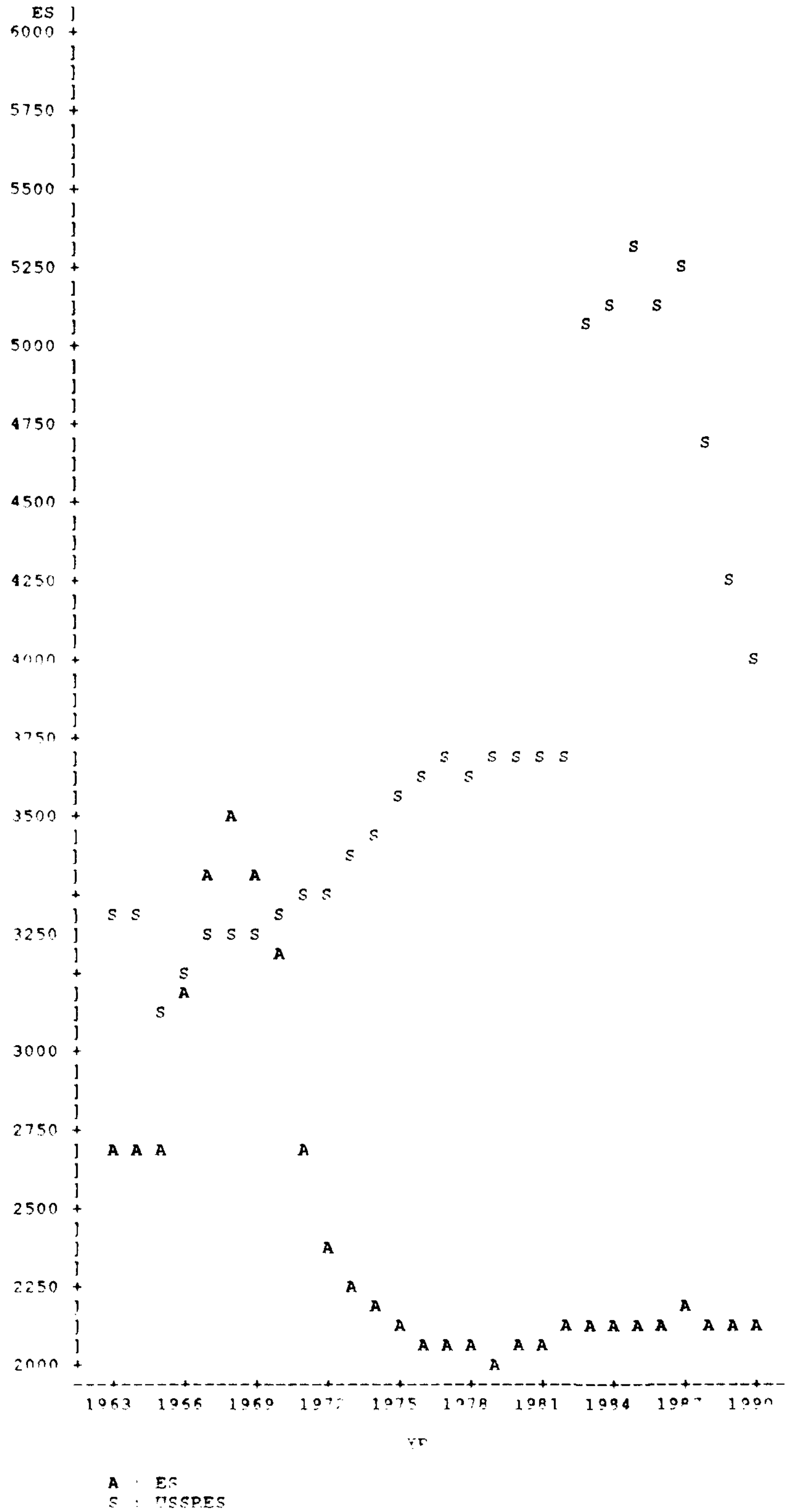

Figure 1 The Trend of ES & USSPES versus YEAR

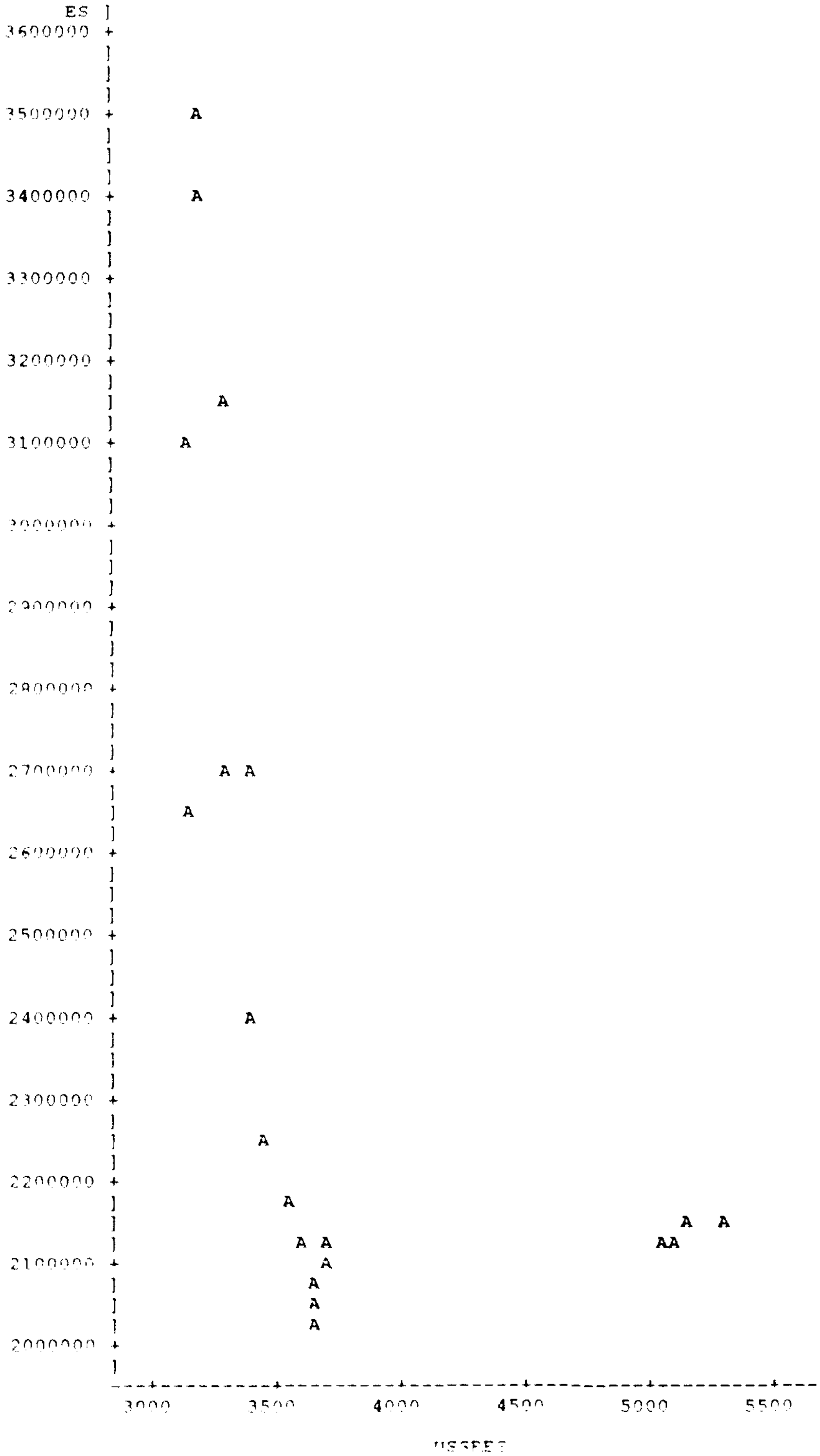

Figure 2. THe Trend of ES versus USSPES

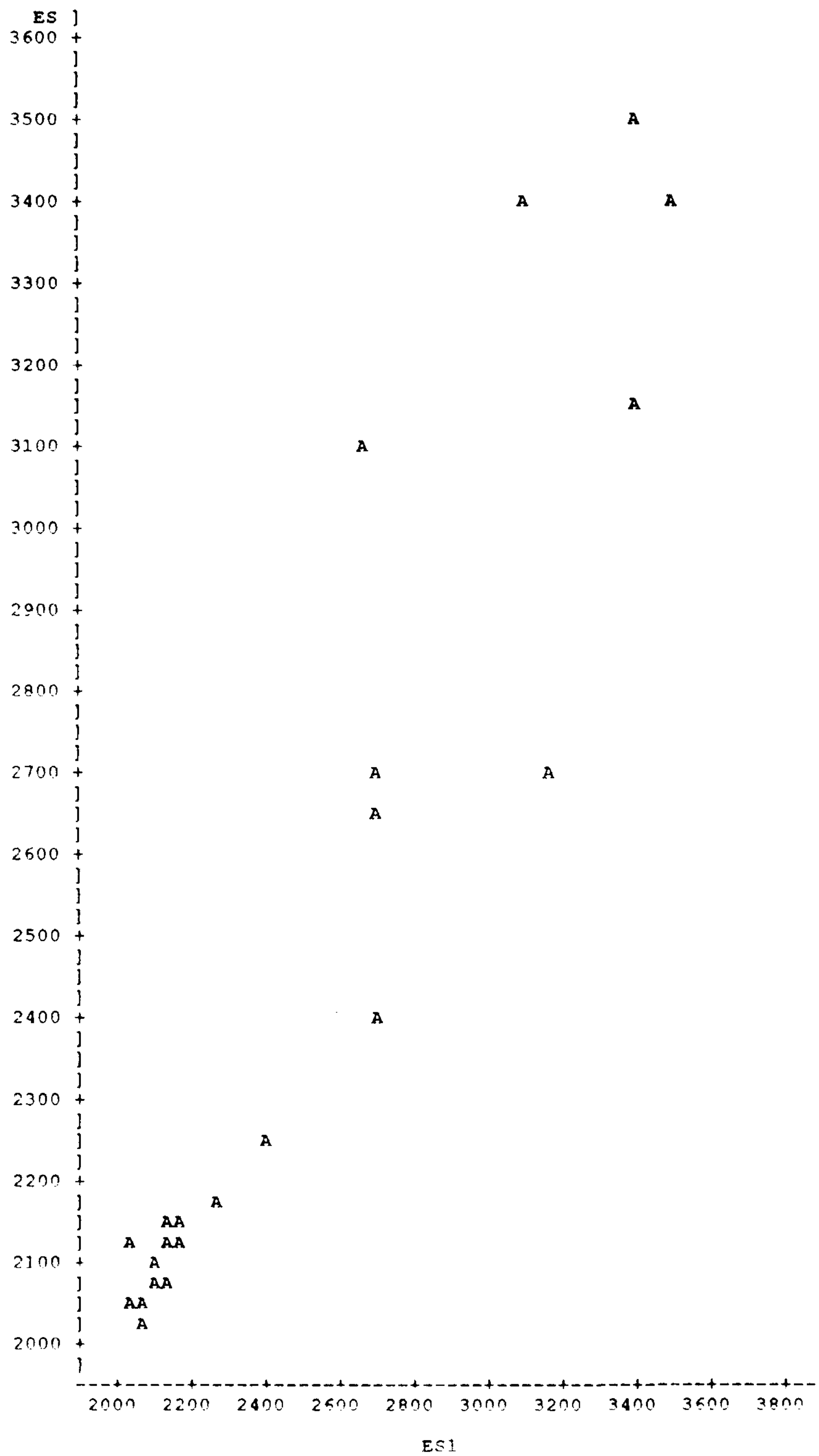

Figure 3 The Trend of ES versus ES1

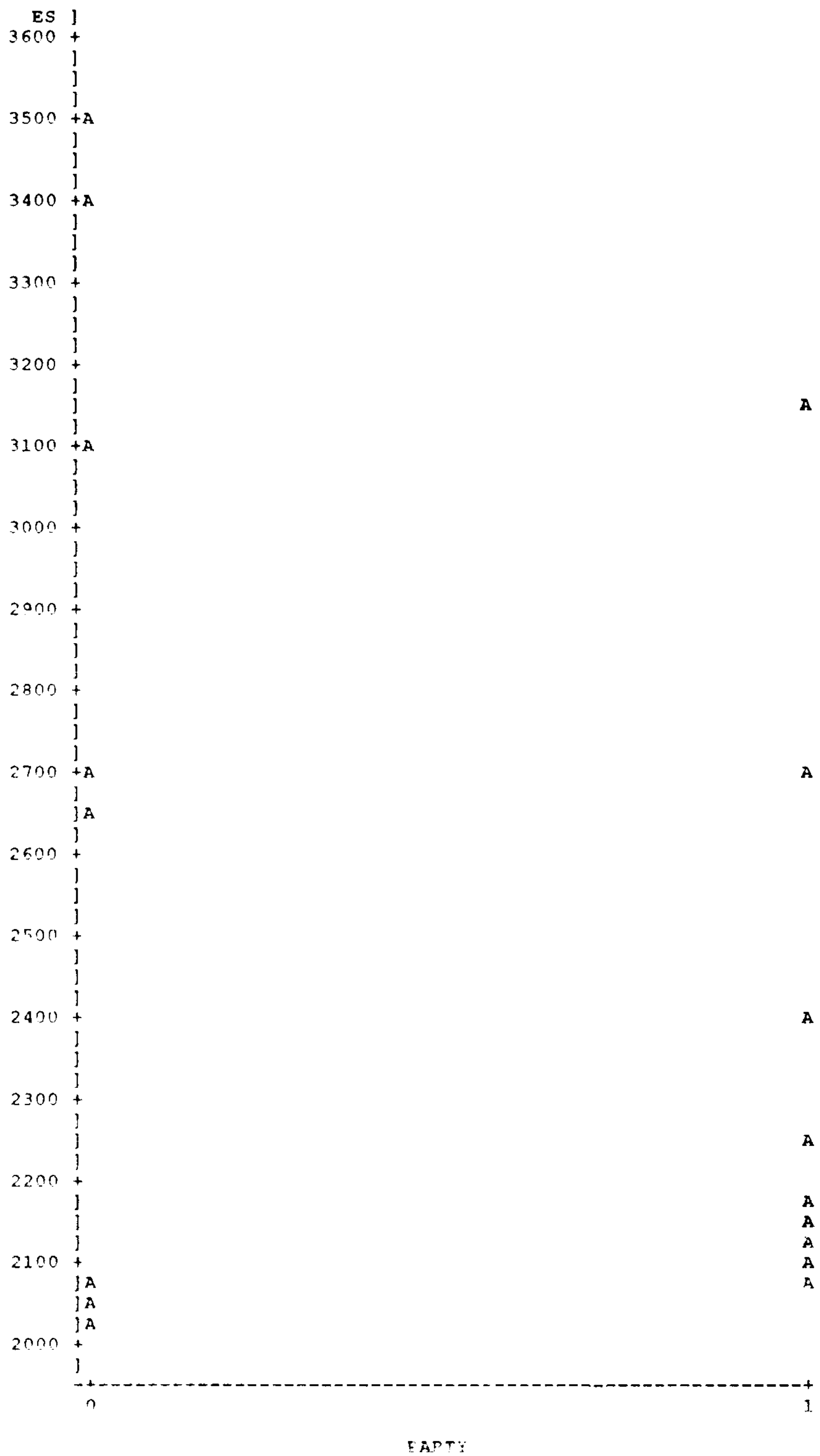

Figure 4. The Trend of ES versus PARTY

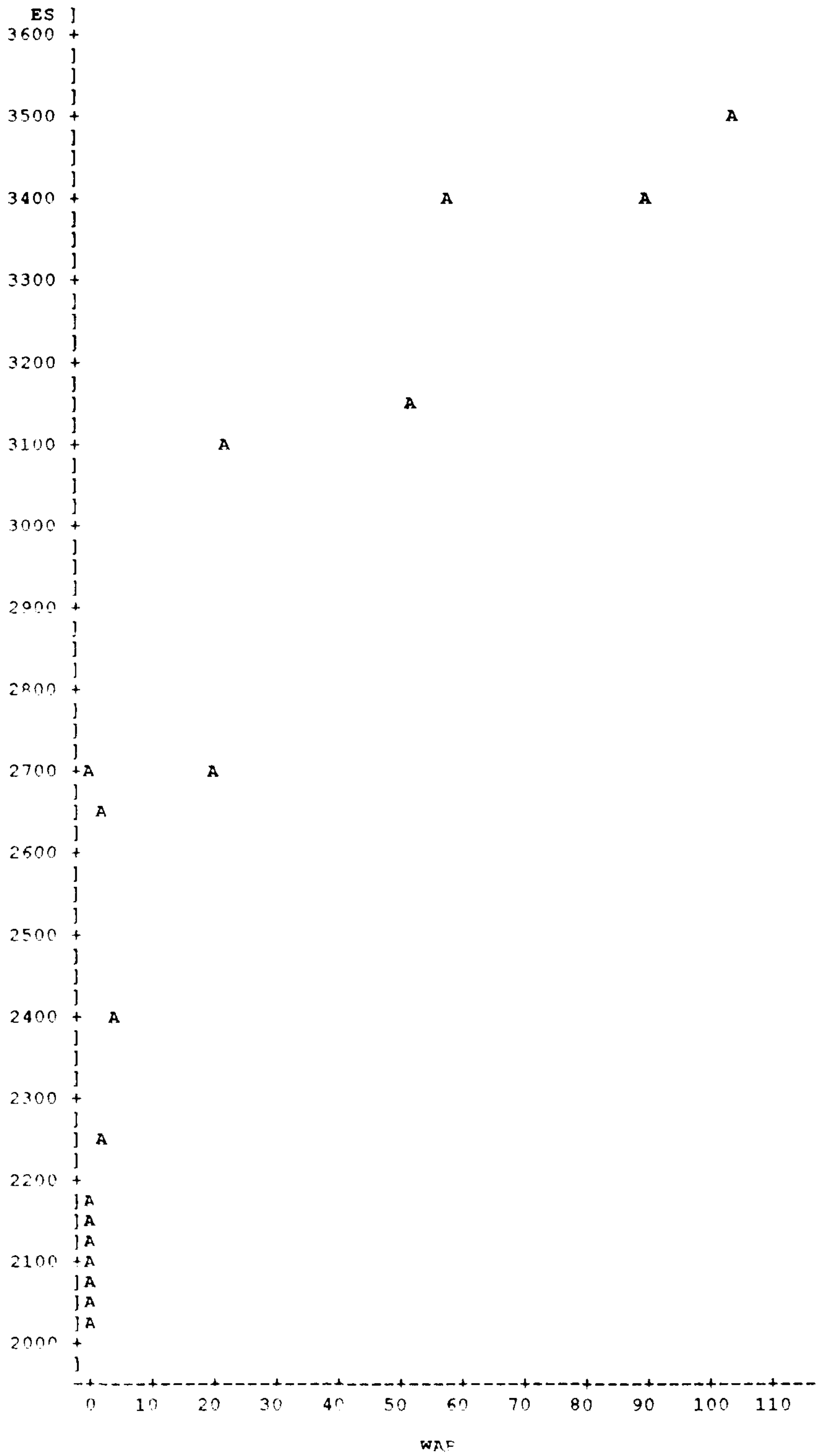

Figure 5 The Trend of ES versus WAP

Based on these relationships, we consider the following candidate model for a stepwise selection:

ES=D(USSRES, USSRES2, USSRES3, ES1, RWAR, GNP, MILPAY, EQUIP, STRUC, CIVPAY, PARTY)

C. **RESULT**

The three alternative demand models selected at the 5% significance level are:

MODEL 1: ES = D (RWAR, ES1)

MODEL 2: ES = D (RWAR, ES1, PARTY)

MODEL 3: ES = D (RWAR, USSRES, USSRES2, USSRES3)

In addition, Deboer and Brorsen's demand model was also fitted based on the new data set:

MODEL 4 : ES = D (MPAYR, KPEQR, KPSTR, CPAYR, PCGNPR, WAR, CARTER, NIXFOR, REAGAN)

One of the dummy variables 'KENJOHN' was eliminated from the analysis due to the changes in the study period.

Estimated demand models are summarized in TABLES 1-4.

TABLE 1

MMDEL 1 : DEMAND MODEL 1 FOR MILITARY LABOR (1963-1986)

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	2	5219670.80	2609835.40	132.246	0.0001
ERROR	20	394693.11	19734.65559		
C TOTAL	22	5614363.91			

ROOT MSE	140.4801	R-SQUARE	0.9297
DEP MEAN	2460.783	ADJ R-SQ	0.9227
C.V.	5.708757		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0
INTERCEP	1	1389.91738	369.95127	3.757
RWAR	1	94.77674279	25.16514297	3.766
ES1	1	0.35019521	0.16825966	2.081

VARIABLE	DF	PROB >]T]
INTERCEP	1	0.0012
RWAR	1	0.0012
ES1	1	0.0505

OBS	ACTUAL	PREDICT VALUE	STD ERR PREDICT	RESIDUAL	STD ER RESIDUA
1	2700.0	.	.	.	
2	2690.0	2414.7	73.3790	[illegible]	119.
3	2660.0	2455.5	61.5337	[illegible]	126.
4	3094.0	2756.8	46.6577	337.2	132.
5	3400.0	3190.9	62.3574	209.1	125.
6	3500.0	3543.4	85.0962	-43.3934	111.
7	3400.0	3518.7	72.3564	-118.7	120.

8	3161.0	3261.4	64.0533	-100.4	125.
9	2699.0	2922.9	68.1670	-223.9	122.
10	2391.0	2517.4	50.0590	-126.4	131.
11	2252.0	2331.1	31.7569	-79.0568	136.
12	2174.0	2178.6	36.4232	-4.5570	135.
13	2130.0	2151.2	34.9327	-21.2418	136.
14	2087.0	2135.8	36.2254	-48.8332	135.
15	2088.0	2120.8	38.8340	-32.7748	135.
16	2062.0	2121.1	38.7600	-52.1250	135.
17	2022.0	2114.5	40.2633	-92.4713	134.
18	2050.0	2098.0	44.7527	-48.0121	133.
19	2049.0	2107.8	41.9567	-58.8176	134.
20	2117.0	2107.5	42.0507	9.5326	134.
21	2136.0	2131.3	36.8840	4.7194	135.
22	2135.0	2137.9	35.9622	-2.9343	135.
23	2151.0	2137.6	36.0042	13.4159	135.
24	2143.0	2143.2	35.4218	-0.1873	135.

OBS	STUDENT RESIDUAL	-2 -1 0 1 2	COOK'S D
1	.		.
2	2.2978	]]****]	0.660
3	1.6192	]]***]	0.207
4	2.5449	]]*****]	0.268
5	1.6615	]]***]	0.226
6	-0.3882	]]]	0.029
7	-0.9859	] *]]	0.117
8	-0.8030	] *]]	0.056
9	-1.8224	] ***]]	0.341
10	-0.9630	] *]]	0.045
11	-0.5777	] *]]	0.006
12	-0.0336	]]]	0.000
13	-0.1561	]]]	0.001
14	-0.3598	]]]	0.003
15	-0.2428	]]]	0.002
16	-0.3860	]]]	0.004
17	-0.6871	] *]]	0.014
18	-0.3606	]]]	0.005
19	-0.4387	]]]	0.006
20	0.0711	]]]	0.000
21	0.0348	]]]	0.000
22	-0.0216	]]]	0.000
23	0.0988	]]]	0.000
24	-.001378	]]]	0.000

SUM OF RESIDUALS 4.54747E-1[illegible]
SUM OF SQUARED RESIDUALS 394693.1
PREDICTED RESID SS (PRESS) 604568

TABLE 2

MODEL 2 : DEMAND MODEL 2 FOR MILITARY LABOR (1963-1986)

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	3	5297951.00	1765983.67	106.044	0.0001
ERROR	19	316412.91	16653.31120		
C TOTAL	22	5614363.91			

ROOT MSE	129.0477	R-SQUARE	0.9436
DEP MEAN	2460.783	ADJ R-SQ	0.9347
C.V.	5.244173		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0
INTERCEP	1	1327.44806	341.06360	3.892
RWAR	1	78.68183042	24.27990143	3.241
ES1	1	0.41811069	0.15770887	2.651
PARTY	1	-127.79119	58.94205022	-2.168

VARIABLE	DF	PROB >]T]
INTERCEP	1	0.0010
RWAR	1	0.0043
ES1	1	0.0158
PARTY	1	0.0431

OBS	ACTUAL	PREDICT VALUE	STD ERR PREDICT	RESIDUAL	STD ERR RESIDUAL
1	2700.0	.	.	.	.
2	2690.0	2522.2	83.6620	167.8	98.2547
3	2660.0	2554.8	72.7345	105.2	106.6
4	3094.0	2801.0	47.4728	293.0	120.0
5	3400.0	3216.7	58.5084	[illegible]	115.0
6	3500.0	3548.3	78.2042	[illegible]	102.7
7	3400.0	3540.6	67.2289	-140.6	110.2
8	3161.0	3186.4	68.2472	-25.4295	109.5
9	2699.0	2874.9	66.4053	-175.9	110.7
10	2391.0	2479.5	49.1983	-88.4852	119.3

11	2252.0	2285.6	35.9384	-33.5512	123.9
12	2174.0	2141.2	37.6261	32.7579	123.4
13	2130.0	2108.6	37.6305	21.3705	123.4
14	2087.0	2090.2	39.3669	-3.2326	122.9
15	2088.0	2072.3	42.1125	15.7461	122.0
16	2069.0	2200.5	51.0575	-131.5	118.5
17	2022.0	2192.5	51.6130	-170.5	118.3
18	2050.0	2172.9	53.6857	-122.9	117.4
19	2049.0	2184.6	52.3345	-135.6	118.0
20	2117.0	2056.4	45.2516	60.6343	120.9
21	2136.0	2084.8	40.0959	51.2028	122.7
22	2135.0	2092.7	39.0621	42.2587	123.0
23	2151.0	2092.3	39.1115	58.6768	123.0
24	2143.0	2099.0	38.3918	43.9870	123.2

OBS	STUDENT RESIDUAL	-2 -1 0 1 2	COOK'S D
1	.		.
2	1.7080	]]***]	0.529
3	0.9873	]]*]	0.113
4	2.4413	]]****]	0.233
5	1.5938	]]***]	0.164
6	-0.4708	]]]	0.032
7	-1.2763	] **]]	0.152
8	-0.2322	]]]	0.005
9	-1.5900	] ***]]	0.228
10	-0.7417	] *]]	0.023
11	-0.2707	]]]	0.002
12	0.2654	]]]	0.002
13	0.1731	]]]	0.001
14	-0.0263	]]]	0.000
15	0.1291	]]]	0.000
16	-1.1092	] **]]	0.057
17	-1.4417	] **]]	0.099
18	-1.0470	] **]]	0.057
19	-1.1493	] **]]	0.065
20	0.5017	]]*]	0.009
21	0.4174	]]]	0.005
22	0.3436	]]]	0.003
23	0.4771	]]]	0.006
24	0.3570	]]]	0.003

SUM OF RESIDUALS	1.30740E-12
SUM OF SQUARED RESIDUALS	316412.9
PREDICTED RESID SS (PRESS)	521962.8

TABLE 3

MODEL 3 : DEMAND MODEL 3 FOR MILITARY LABOR (1963-1986)

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	4	5499513.10	1374878.28	215.478	0.0001
ERROR	18	114850.81	6380.60067		
C TOTAL	22	5614363.91			

ROOT MSE	79.87866	R-SQUARE	0.9795
DEP MEAN	2460.783	ADJ R-SQ	0.9750
C.V.	3.246067		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0
INTERCEP	1	29972.09132	8640.50534	3.469
RWAR	1	99.79603626	7.82963188	12.746
USSRES	1	-18.54746417	6.57743880	-2.820
USSRES2	1	0.004045672	0.001648252	2.455
USSRES3	1	-2.89975E-07	1.35350E-07	-2.142

VARIABLE	DF	PROB >]T]
INTERCEP	1	0.0027
RWAR	1	0.0001
USSRES	1	0.0113
USSRES2	1	0.0245
USSRES3	1	0.0461

OBS	ACTUAL	PREDICT VALUE	STD ERR PREDICT	RESIDUAL	STD ERR RESIDUAL
1	2700.0	2456.7	36.6915	.	.
2	2690.0	2485.5	34.9387	204.5	71.8324
3	2660.0	2757.5	57.9980	-97.4548	54.9258
4	3094.0	3060.7	38.9978	33.3335	69.7121
5	3400.0	3270.6	32.5042	129.4	72.9663
6	3500.0	3529.0	45.8198	-29.0265	65.4305
7	3400.0	3466.2	42.0725	-66.1713	67.9007
8	3161.0	3112.3	32.6173	48.7064	72.9158
9	2699.0	2758.0	23.5567	-59.0462	76.3262

10	2391.0	2501.5	22.9326	-110.5	76.5160
11	2252.0	2364.2	23.4898	-112.2	76.3468
12	2174.0	2161.3	24.3358	12.7171	76.0813
13	2130.0	2122.0	24.0123	8.0473	76.1840
14	2087.0	2071.7	25.6094	15.3383	75.6622
15	2088.0	2057.1	26.6626	30.8896	75.2974
16	2069.0	2079.0	25.1926	-10.0311	75.8019
17	2022.0	2066.9	25.9196	-44.8882	75.5564
18	2050.0	2066.9	25.9196	-16.8882	75.5564
19	2049.0	2058.2	26.5694	-9.2351	75.3304
20	2117.0	2041.0	28.2381	75.9533	74.7209
21	2136.0	2137.0	53.6261	-0.9595	59.2017
22	2135.0	2143.8	42.9336	-8.7687	67.3595
23	2151.0	2142.9	75.6632	8.1456	25.6062
24	2143.0	2144.9	41.4002	-1.8726	68.3127

OBS	STUDENT RESIDUAL	-2 -1 0 1 2	COOK'S D
1	.		.
2	2.8470	]]*****]	0.384
3	-1.7743	] ***]]	0.702
4	0.4782	]]]	0.014
5	1.7728	]]***]	0.125
6	-0.4436	]]]	0.019
7	-0.9745	] *]]	0.073
8	0.6680	]]*]	0.018
9	-0.7736	] *]]	0.011
10	-1.4439	] **]]	0.037
11	-1.4692	] **]]	0.041
12	0.1672	]]]	0.001
13	0.1056	]]]	0.000
14	0.2027	]]]	0.001
15	0.4102	]]]	0.004
16	-0.1323	]]]	0.000
17	-0.5941	] *]]	0.008
18	-0.2235	]]]	0.001
19	-0.1226	]]]	0.000
20	1.0165	]]**]	0.030
21	-0.0162	]]]	0.000
22	-0.1302	]]]	0.001
23	0.3181	]]]	0.177
24	-0.0274	]]]	0.000

SUM OF RESIDUALS 5.41149E-10
SUM OF SQUARED RESIDUALS 114850.8
PREDICTED RESID SS (PRESS) 198675.5

TABLE 4

MODEL 4 : DEBOER and BRORSEN's DEMAND MODEL (1963-1986)

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	9	5537871.24	615319.03	87.375	0.0001
ERROR	12	84507.53439	7042.29453		
C TOTAL	21	5622378.77			

ROOT MSE	83.91838	R-SQUARE	0.9850
DEP MEAN	2447.682	ADJ R-SQ	0.9737
C.V.	3.428484		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0
INTERCEP	1	3977.07489	1054.36949	3.772
MPAYR	1	-0.04693228	0.03682841	-1.274
KPEQR	1	1428.17944	731.28161	1.953
KPSTR	1	-1448.68051	697.32834	-2.077
CPAYR	1	-0.08459454	0.05623848	-1.504
PCGNPR	1	0.11597559	0.06810544	1.703
WAR	1	7.66143836	1.35536513	5.653
CARTER	1	115.13584	234.57099	0.491
NIXFOR	1	218.17385	193.32807	1.129
REAGAN	1	247.94413	216.90492	1.143

VARIABLE	DF	PROB >]T]
INTERCEP	1	0.0027
MPAYR	1	0.2267
KPEQR	1	0.0745
KPSTR	1	0.0599
CPAYR	1	0.1584
PCGNPR	1	0.1143
WAR	1	0.0001
CARTER	1	0.6324
NIXFOR	1	0.2812
REAGAN	1	0.2753

OBS	ACTUAL	PREDICT VALUE	STD ERR PREDICT	RESIDUAL	STD ERR RESIDUAL
1	2700.0	2856.6	108.2	.	.
2	2687.0	2752.2	78.1640	.	.

3	2655.0	2768.7	63.1526	-113.7	55.2633
4	3094.0	2983.8	52.0196	110.2	65.8502
5	3377.0	3313.0	48.9035	64.0433	68.1963
6	3548.0	3586.5	65.3137	-38.5259	52.6917
7	3460.0	3482.1	67.9300	-22.0705	49.2728
8	3066.0	3105.1	71.5604	-39.1345	43.8338
9	2715.0	2623.0	47.5441	92.0227	69.1510
10	2323.0	2238.6	52.6729	84.3591	65.3288
11	2253.0	2231.6	49.7622	21.4209	67.5723
12	2162.0	2281.1	57.0059	-119.1	61.5843
13	2128.0	2114.7	46.6425	13.3006	69.7623
14	2082.0	2101.1	44.8049	-19.1433	70.9564
15	2075.0	2108.7	64.7580	-33.7203	53.3732
16	2062.0	2047.5	67.1964	14.5303	50.2687
17	2027.0	2099.7	45.5062	-72.6791	70.5087
18	2051.0	2086.4	53.0829	-35.4447	64.9962
19	2083.0	1989.4	66.6688	93.5936	50.9663
20	2109.0	2112.1	63.7102	-3.0564	54.6196
21	2123.0	2149.8	50.0197	-26.7758	67.3820
22	2138.0	2171.3	46.2909	-33.2621	69.9961
23	2151.0	2136.5	44.7965	14.4874	70.9617
24	2167.0	2118.4	60.3257	48.6069	58.3361

OBS	STUDENT RESIDUAL	-2 -1 0 1 2	COOK'S D
1	.		.
2	.		.
3	-2.0572	] ****]]	0.553
4	1.6741	]]***]	0.175
5	0.9391	]]*]	0.045
6	-0.7312	] *]]	0.082
7	-0.4479	]]]	0.038
8	-0.8928	] *]]	0.212
9	1.3308	]]**]	0.084
10	1.2913	]]**]	0.108
11	0.3170	]]]	0.005
12	-1.9340	] ***]]	0.320
13	0.1907	]]]	0.002
14	-0.2698	]]]	0.003
15	-0.6318	] *]]	0.059
16	0.2891	]]]	0.015
17	-1.0308	] **]]	0.044
18	-0.5453	] *]]	0.020
19	1.8364	]]***]	0.577
20	-0.0560	]]]	0.000
21	-0.3974	]]]	0.009
22	-0.4752	]]]	0.010
23	0.2042	]]]	0.002
24	0.8332	]]*]	0.074

SUM OF RESIDUALS	2.27942E-11
SUM OF SQUARED RESIDUALS	84507.53
PREDICTED RESID SS (PRESS)	334894.5

First of all, many of the independent variables in Deboer and Brorsen's model (Table 4) turned out to be statistically insignificant: MPAY(0.23), CPAYR(0.16), CARTER(0.63), NIXFORD (0.28), REAGAN(0.28). It indicated that Deboer and Brorsen's model is sensitive to the change of time horizon that covers the analysis. A more robust model was necessary for prediction purposes.

In comparison to their model, Model 1, Model 2, and Model 3 are parsinomious and have all significant predictors. In order to compare the robustness of the three models, this thesis used PRESS. The definition of PRESS (Predicted Residual Sum of Squares) is the squared sum of the ith residuals divided by (1-h) where h is the leverage above, and residuals are obtained from the model has been refit without the ith observation. One average prediction error is given by:

$$\sqrt{\frac{PRESS}{N}}$$

where N= number of observations

Model 1;

Average Prediction Error $= \sqrt{\frac{604568}{22}} = 166$

Model 2 ;

$$\text{Average Prediction Error} = \sqrt{\frac{521969}{22}} = 154$$

Model 3 ;

$$\text{Average Prediction Error} = \sqrt{\frac{198675}{22}} = 95$$

In terms of press, this study found that Model 3 has the smallest error for prediction of the military labor demand. Using the actual data (1987-1990), we compared the prediction success of these three models in terms of mean square error (MSE).

TABLE 5

THE MEAN SQUARE ERROR FOR THREE ALTERNATIVE DEMAND MODEL

YEAR	MODEL 1 $(\hat{ES}-ES)^2$	MODEL 2 $(\hat{ES}-ES)^2$	MODEL 3 $(\hat{ES}-ES)^2$
1987	310.26	3885.27	116.1
1988	244.57	787.38	4647.2
1989	1673.15	95.77	17448.0
1990	260.73	888.02	26250.7
MSE	622.173	1414.11	12115.5

$\hat{ES}$: Estimated ES based on the model.

Table 5 shows that Model 3 has the largest MSE while Model 1 has the smalleast MSE, which contradicts the results obtained using PRESS. It can be attributable to the changed patterns in USSRES's end-strength in the late 1980s compared to 1960s through early 1980s. If USSR's end-strength has increased with the similar trend as before, Model 3 might have resulted in the minimum MSE. However that is not the case. Under the current situation, Model 1 seems to provide better predictions than Model 3.

IV. MILITARY LABOR SIMULATION

The following simulations were designed to assess implications of the demand models for manpower planning through the year 2000. Simulations were run to test the impact of war casualties, USSR's end-strength and bipartisan administrations on military labor demand. In the simulation, four different scenarios that reflect the possible combinations of war casualties, USSR's end-strength and presidential administration were considered.

The simulation assumed a 1 percent, 2 percent, and 5 percent annual decrease in USSR's end-strength and no war in scenario 1-3, respectively. The presidential administration was assumed that there will be a republican administration until 1995, then a democratic administration will appear during 1996-1999. In scenario 4, it was assumed that there will be a war from 1994 to 1996 and the annual decrease rate of USSR's end-strength is 1 percent. During the war, 7200 war casualties were expected. Details regarding four scenarios and resulting U.S. end-strength are in TABLE 6-TABLE 9. Simulation results are shown in Figure 6-Figure 9.

Predicted patterns of U.S. end-strength (PREES1 and PREES2) in Figure 6-8 correspond to scenario 1, 2 and 3. According to model 1, U.S. end-strength (PREES1) is expected to decrease from 2,160,000 in 1991 to 2,138,000 in 2000 while model 2 provides the impact of the possible change in bipartisan administration (from Republican to Democratic administration) on the future demand of end-strength.

Model 3 has been examined under three different scenarios (1, 2 and 3) regarding the changing USSR's end-strength along with no war assumption. The resulting patterns in Figure 6 and 7 show that decrease in the predicted U.S. end-strength in the first two years (1991 and 1992) and the subsequent increase between 1993 and 2000 under scenario 1 and 2 while except for 1991, continuous increase is predicted under scenario 3. Under the scenario 1, model 3 consistently predicts the lowest annual end-strength among three models considered. However, under scenario 2 and 3, annual end-strength increases more rapidly than that under scenario 1. Figure 7 indicates that PREES3 starts to exceed PREES1 in 1996 while Figure 8 shows that PRESS3 overrides PRESS1 from 1993.

Figure 9 which corresponds to scenario 4 can be compared to Figure 6 which shows the patterns of predicted end-strength under scenario 1. Differences between scenario 1 and 4 are the expected numbers of war casualties. Under scenario 4, model 1, 2 and 3 provide similar trends during the possible war, which indicates the contribution of the expected number of war casualties on the predicted demand for U.S. end-strength.

TABLE 6

SIMULATION RESULT 1 : SCENARIO 1

SCENARIO 1				END-STRENGTH		
YEAR	WAR	PARTY	USSRES	PREES1	PREES2	PREES3
1991	0	1	3948	2160	2108	1991
1992	0	1	3908	2146	2081	1968
1993	0	1	3869	2141	2069	1978
1994	0	1	3830	2139	2065	1989
1995	0	1	3792	2139	2063	2002
1996	0	0	3754	2139	2190	2017
1997	0	0	3717	2139	2243	2035
1998	0	0	3679	2138	2265	2054
1999	0	0	3643	2138	2274	2075
2000	0	1	3606	2138	2150	2099

PREES i: Predicted End-Strength based on model i.
USSRES: Annual decrease rate, 1 percent.
WAR: No war.

TABLE 7

SIMULATION RESULT 2 : SCENARIO 2

SCENARIO 2				END-STRENGTH		
YEAR	WAR	PARTY	USSRES	PREES1	PREES2	PREES3
1991	0	1	3908	2160	2108	1998
1992	0	1	3830	2146	2081	1989
1993	0	1	3753	2141	2069	2018
1994	0	1	3678	2139	2065	2055
1995	0	1	3604	2139	2063	2100
1996	0	0	3532	2139	2190	2154
1997	0	0	3462	2139	2243	2217
1998	0	0	3392	2138	2265	2289
1999	0	0	3324	2138	2274	2369
2000	0	1	3258	2138	2150	2458

USSRES: Annual decrease rate, 2 percent
WAR: No war.

TABLE 8

SIMULATION RESULT 3 : SCENARIO 3

SCENARIO 3				END-STRENGTH		
YEAR	WAR	PARTY	USSRES	PREES1	PREES2	PREES3
1991	0	1	3788	2160	2108	2033
1992	0	1	3599	2146	2081	2104
1993	0	1	3419	2141	2069	2260
1994	0	1	3248	2139	2065	2473
1995	0	1	3085	2139	2063	2741
1996	0	0	2931	2139	2190	3062
1997	0	0	2784	2139	2243	3432
1998	0	0	2645	2138	2265	3849
1999	0	0	2513	2138	2274	4307
2000	0	1	2387	2138	2150	4803

USSRES: Annual decrease rate, 5 percent.
WAR: No war.

TABLE 9

SIMULATION RESULT 4 : SCENARIO 4

SCENARIO 4				END-STRENGTH		
YEAR	WAR	PARTY	USSRES	PREES1	PREES2	PREES3
1991	0	1	3948	2160	2108	1991
1992	0	1	3908	2146	2081	1968
1993	0	1	3869	2141	2069	1978
1994	1.5	1	3830	2139	2065	1989
1995	3.5	1	3792	2281	2181	2152
1996	2.2	0	3754	2520	2514	2366
1997	0	0	3717	2481	2552	2254
1998	0	0	3679	2258	2394	2054
1999	0	0	3643	2180	2328	2075
2000	0	1	3606	2153	2173	2099

USSRES: Annual decrease rate, 1 percent.
WAR: 7200 war casualties were expected

PLOT OF PREES1*YR   SYMBOL USED IS 1
PLOT OF PREES2*YR   SYMBOL USED IS 2
PLOT OF PREES3*YR   SYMBOL USED IS 3

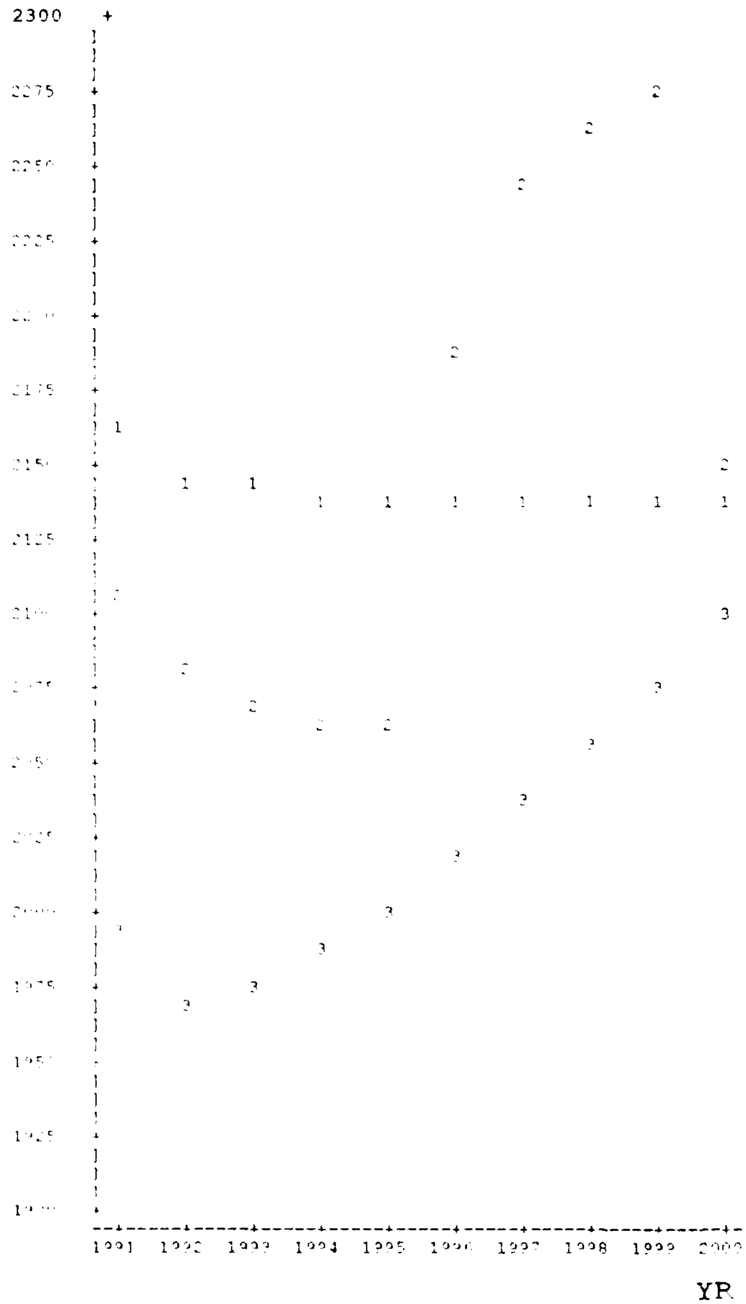

Figure 6. The Plot of PREES1, PREES2, PREES3 versus YEAR for Scenario 1

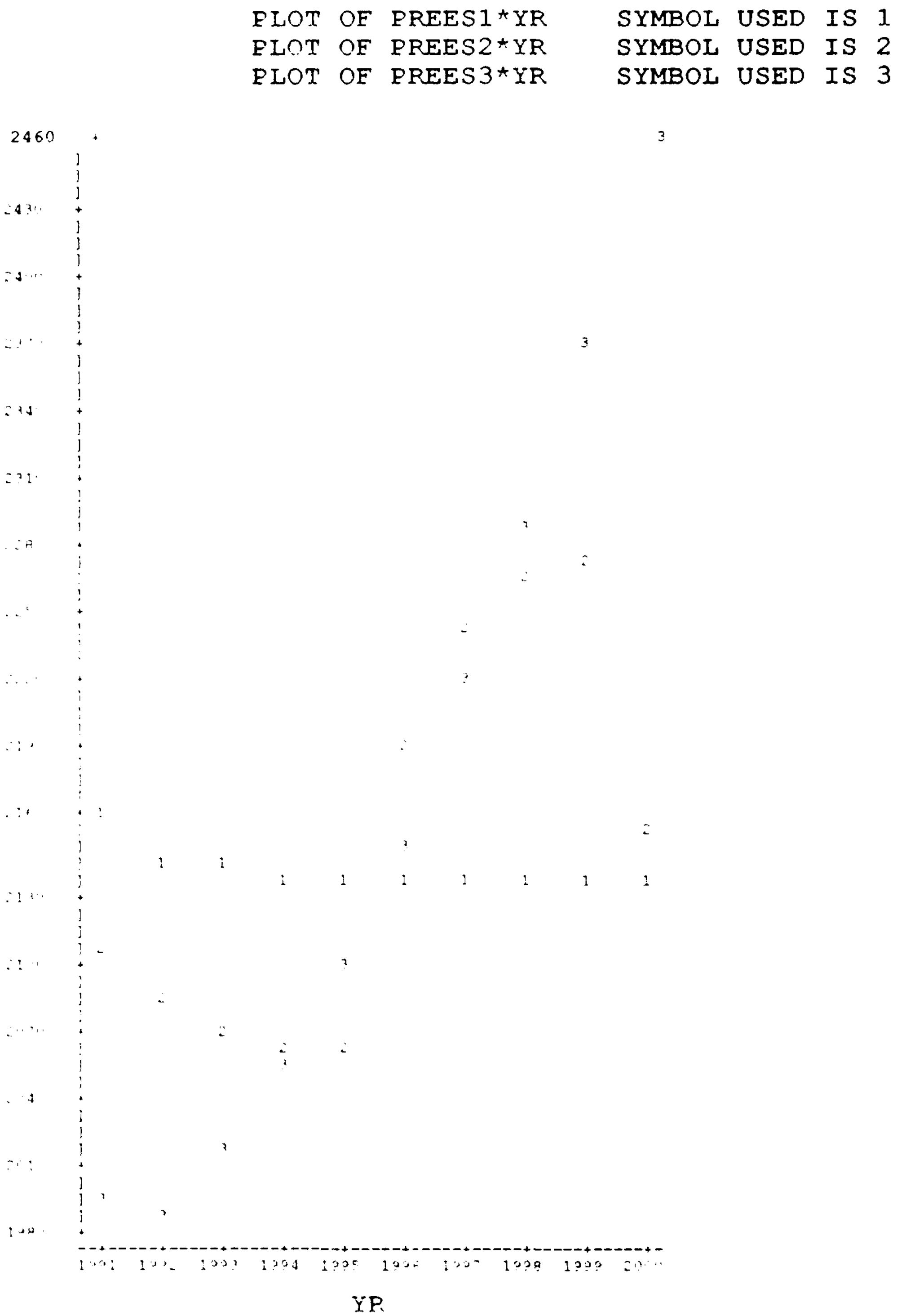

Figure 7. The Plot of PREES1,PREES2,PREES3 versus YEAR for Scenario 2

PLOT OF PREES1*YR   SYMBOL USED IS 1
PLOT OF PREES2*YR   SYMBOL USED IS 2
PLOT OF PREES3*YR   SYMBOL USED IS 3

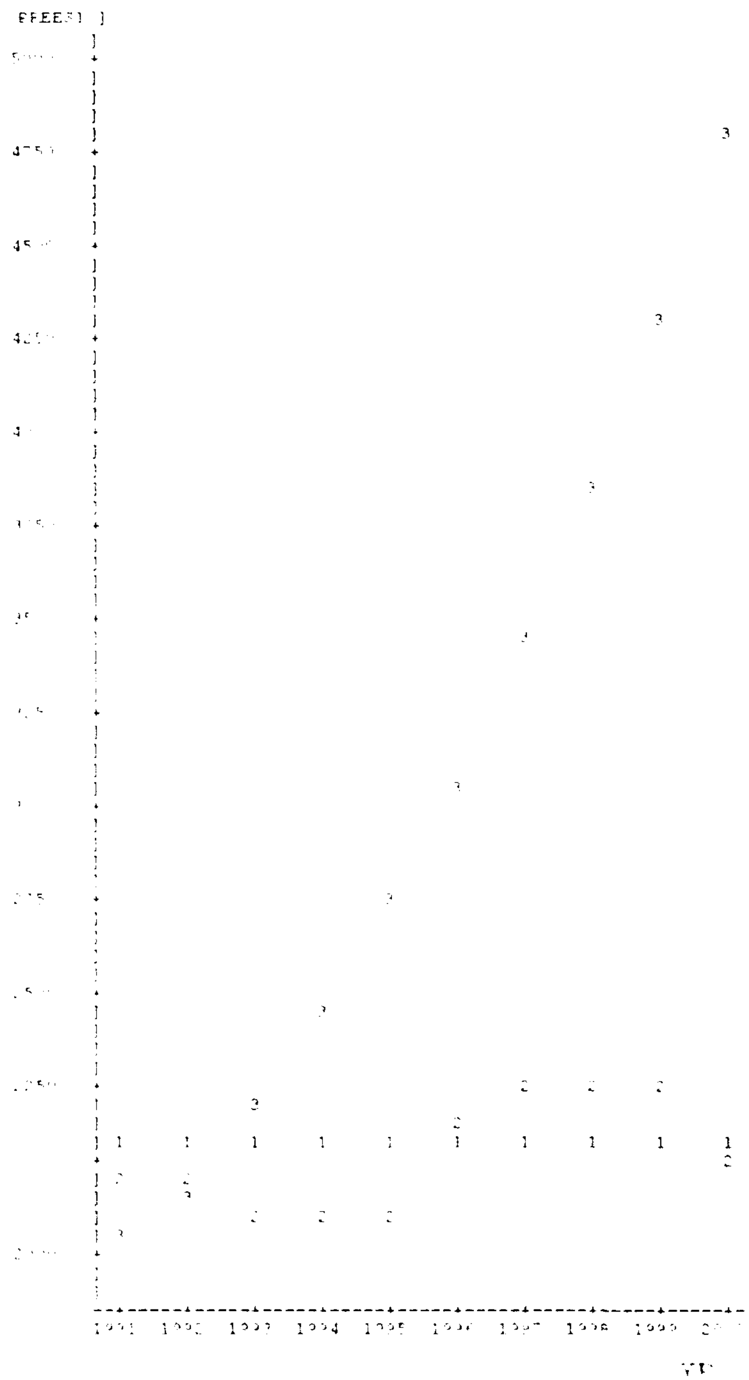

Figure 8.   The Plot of PREES1,PREES2,PREES3 versus YEAR for Scenario 3

PLOT OF PREES1*YR   SYMBOL USED IS 1
PLOT OF PREES2*YR   SYMBOL USED IS 2
PLOT OF PREES3*YR   SYMBOL USED IS 3

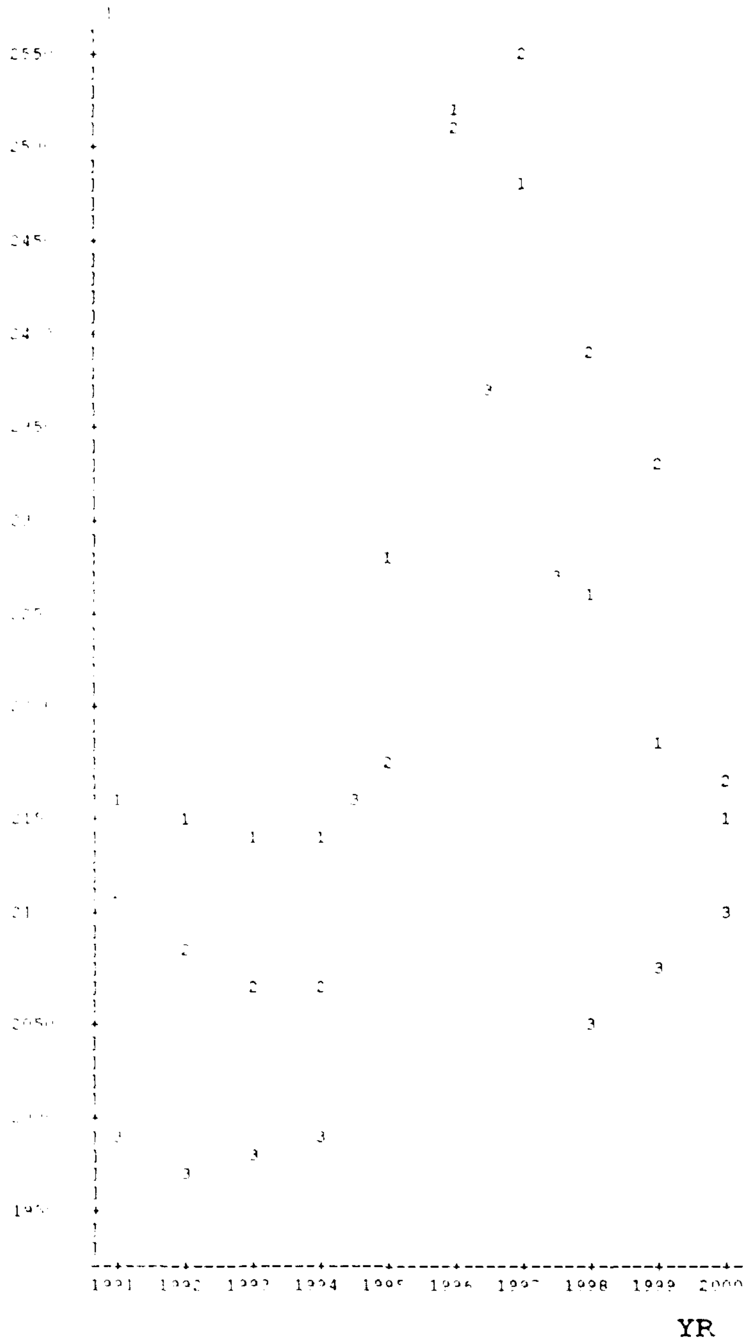

Figure 9. The Plot of PREES1,PREES2,PREES3 versus YEAR for Scenario 4

V. SUMMARY

Misassessment of demand for defense manpower can cause disastrous consequences. In this thesis, prediction models for U.S. military labor demand are formulated in terms of war casualties, bipartisan administration, the past year's U.S. end-strength and USSR's end-strength. If changes in USSR's end-strength in the 1990s are similar to those in the 1960s through the early 1980s, Model 3, D(USSPES, USSRES2, USSRES3, RWAR) can be used as a robust prediction model. An interesting finding in Model 3 is U.S. end-strength as a function of a third degree of polynomial USSR's end-strength and square root of the number of war casualties.

Recent unprecedented changes in the USSR, however, may deter us from using Model 3 to decide demand for U.S. end-strength in the near future. For a short term prediction, Model 1 [D(ES1, RWAR)] or Model 2 [D(ES1, RWAR, PARTY)] may provide better predictions than Model 3.

In comparison to the existing models, prediction models considered in this thesis are relatively parsinomious but provide accurate predictions. Although these models were considered for U.S. end-strength, similar considerations can be made for the prediction of military labor demand in other countries. Results of simulation studies can be used to assist defense manpower policy.

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