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Models of Compensation (MODCOMP): Policy Analyses and Unemployment Effects

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14. ABSTRACT

The overall objective of this research is to analyze the impact of wage and bonus increases on enlisted personnel as well as personnel behavior over time and sensitivity to the macroeconomic conditions. Two types of models are used: the Amortized Cost of Leaving (ACOL) maximum likelihood and the non-ACOL information theoretic Generalized Maximum Entropy (GME) method. The bonus experiments for the ACOL models are done in the traditional manner and a way to improve those is discussed. The experiments for the non-ACOL model are developed and studied here.

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Foreword

The overall objective of this research is to analyze the impact of wage and bonus increases on enlisted personnel as well as personnel behavior over time and sensitivity to the macro economic conditions. Two types of models are used: the Annualized Cost of Leaving (ACOL) maximum likelihood (ML) and the non-ACOL information theoretic Generalized Maximum Entropy (GME) method. The bonus experiments for the ACOL models are done in the traditional way and a way to improve those is discussed. The experiments for the non-ACOL model are developed and studied here.

Some of the main findings are:

1. A full comparison of the binary and multinomial cases is done where it is shown that the multinomial models are more sensitive to increase in Selective Reenlistment Bonus (SRB).
2. A detailed analysis by Zone reveals that sensitivity to SRB increases with the length of service.
3. Analysis by year (1996–2002) reveals that the sensitivity to SRB is slowly declining throughout the period analyzed.
4. The sensitivity to the unemployment rate is decreasing over time.
5. The above results are robust across the four professions analyzed (Weapons Control, Sensor Operations, General Seamanship, and Administration).

David L. Alderton, Ph.D.
Director

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Introduction

Background and Objectives

Within the objectives of Models of Compensation (MODCOMP) and the new non-ACOL and ACOL Information Theoretic Models developed earlier (Golan, 2003), the basic set of objectives in this stage of the research is to examine the different models using recent data and to develop the necessary tools to aid policy makers in their decision process involving Navy personnel. Specifically, in this study the objectives are:

1. Study the impact of SRB and other pay increases on retention.
2. Study the impact of unemployment on retention.
3. Compare and contrast the GME non-ACOL model with the ML ACOL model.

To achieve these goals, a detailed study of four Navy skill groups was done. These skill groups are Weapons Control, Sensor Operations, Administration, and General Seamanship. These groups were chosen because they represent the broad spectrum of Navy personnel. For each of these groups, the ACOL and non-ACOL models were used to investigate the above three objectives for the group as a whole, for subgroups (such as Zone A, B, and C), as well as over time. Further, all estimations were repeated for different choices (binary: leave, reenlist; 3-choice: leave, extend, reenlist; 4-choice: leave, short-extension, long extension, and reenlist). For the ACOL models used here, all analyses were repeated for different discount factors (5% through 40%) and for different sets of variables. This detailed set of estimations was needed in order to compare and contrast our estimates with all other recent (and less recent) studies (i.e., Hansen & Wegner, 2002; Asch & Warner, 2001; Goldberg, 2001).

For completion we begin the next subsection with a brief summary of the Navy Models of Compensation (MODCOMP). (A complete specification of that model, the econometric background and model formulation, as well as detailed analysis of all basic Navy skills, is provided in Golan, 2003.) Next we provide a discussion of the current way the SRB experiments are done and the major problems with these experiments and their applications. Keeping these problems in mind, a different way to perform SRB experiments within the more traditional ACOL framework and the non-ACOL framework is then provided and discussed. The following section provides three very detailed examples and discussion of the SRB experiment in the non-ACOL models as well as the ACOL models. A detailed analysis of out-of-sample forecasting of SRB experiments is then presented. Using real data the forecasted results of many models are compared and contrasted with the correct values. Finally, unemployment analysis, some basic out-of-sample forecasting comparisons of the models investigated here, and some concluding remarks and ideas for future directions and research are provided.

The Basic MODCOMP—A Brief Overview

Retention forecasting models are important tools for managers of large businesses. These models are even more important for managing Navy and other military personnel. All of these types of models are within the class of discrete choice, or in most cases, the binary choice models. Since the seminal work of Warner and Goldberg (1984), who introduced the notion of Annualized Cost of Leaving (ACOL), all models build on that approach under the assumption of normality, thereby using the Maximum Likelihood (ML) probit (normally distributed errors) model. For some additional applications of such a model and recent nice review see Mehay and Hogan (1998) and Mehay (2001).

Within this general scope of developing an up-to-date retention set of models for Navy personnel, a different econometric approach was developed (Golan, 2003). As the policy makers need to update their compensation packages frequently, the method developed is easy to use, simple to apply, and new data are easily incorporated. The new method developed is a member of the Information-Theoretic class of estimation methods and is a generalization of the traditional Maximum Likelihood Logit. In addition to the detailed analytical formulation, the necessary statistics and diagnostics as well as software were developed.

The main advantages of this new Information-Theoretic model are that it is more flexible, uses fewer assumptions, is semi-parametric, includes the traditional maximum likelihood method as a special case, and allows the users to incorporate prior information and any other type of soft data such as economic theory.

The new method, called generalized maximum entropy (GME), has its roots in information theory (Shannon, 1948) and builds on the classical maximum entropy formalism (ME) of Jaynes (1957a, 1957b, 1984) that was developed specifically for evaluating and processing the information of under-determined, ill-posed problems and imperfect data. For extensions, applications, and nice axiomatic derivations see, for example, Good (1963), Shore and Johnson (1980) and Skilling (1989). This ME formalism was generalized by Golan, Judge, and Miller (1996) and Golan, Judge, and Perloff (1996). This generalization is the basis for the statistical formulation used in this paper. For review of both the classical ME and GME approaches (see Golan et al., 1996; and Golan, 2002).

The main advantages of this approach are summarized below.

1. Easy to use and apply and statistically and computationally efficient.
2. The GME performs well for small and/or ill-behaved (highly collinear) data (even at the tails of the distribution). *The Navy personnel data falls within these categories.*
3. This formulation allows a direct informational interpretation of all relevant statistics.
4. GME uses less a-priori assumptions than the ML approach.
5. GME is a semi-parametric approach and therefore has a very flexible distribution.

6. Easy to incorporate additional (theoretical) knowledge/information (soft data, priors).
7. GME is a direct generalization of the ML—but without added complexity.
8. GME is more stable and robust than the ML (i.e., estimates will have smaller variances).
9. Like Bayesian methods, allows use of prior knowledge, but easier to apply and does not use a pre-specified likelihood.
10. Easy to compute and apply and available in LIMDEP and SAS (version 9), and in other packages.
11. Under this framework the relevant macroeconomic conditions (local and global) can be easily incorporated.
12. The objective function has equal weights for two components: goodness of predictive fit and precision of parameter estimation. Non-equal weights can be incorporated as well by imposing weights α and 1- α on the two components of the objective function.
13. Instead of a regularization parameter, or a-priori assumptions on the exact nature of the relationship between the observed sample moments and the unobserved moments of the population, the regularization appears through the pre-specified bounds on the errors' support space.

Selective Reenlistment Bonus (SRB) and Other Pay Incentives

The ACOL Model

The SRB ACOL experiments (in all existing literature as well as in our current ACOL model) are done as follows:

Step 1. Given a certain discount factor determined by the researcher, the ACOL value for each individual is calculated (for a specific group).

Step 2. Estimate the ACOL Maximum Likelihood (ML) binary model (for the specific group). Use the estimated coefficients to predict the individuals' reenlistment probabilities. These probabilities are then averaged over individuals to give the mean predicted reenlisted probability

Step 3. Increase SRB by exactly one unit for entitled personnel.

Step 4. Recalculate the ACOL value for each individual (with the increased SRB). Specifically, to calculate the impact of an SRB increase on the mean reenlistment probability, a new ACOL value for each individual is calculated after allowing a "theoretical" increase of SRB by one point. The ACOL calculator calculates the new ACOL values, while maintaining the basic rules of entitlement (e.g., only individuals in Zones A–C, etc., are entitles if they signed for at least 3 years).

Step 5. Using the estimated coefficients from Step 2, recalculate the reenlistment probability for each individual (with the new ACOL value calculated in Step 4). Then, calculate the expected value (over individuals) of the resulting reenlistment probability.

Step 6. The percent difference between the mean probabilities of Stages 5 and 2 are called the Percentage Point (ppt) Increase in reenlistment due to an increase in SRB by a unit.

With this in mind, we now discuss the basic flaws of that approach and the way these estimates are used by the policy makers.

1. The different ACOL calculators (see the ACOL theoretical and applied literature) use different underlying assumptions. Therefore, using the same data and same discount factors, different calculators/models yield different ACOL values.
2. Most models use a discount factor of only 10–20 percent. This may result in an under-estimated (predicted) value of the SRB effect. Example: A one unit increase in SRB for the Weapons Control group (1995–2002) yields a 0.3 percentage point (ppt) increase under ACOL with a 10 percent discount factor, a 1.1 ppt increase under ACOL with a 20 percent discount factor, and a 3.4 ppt increase under ACOL with a 40 percent discount factor (or 3.6 ppt under the same model, but with three choices: leave, extend, reenlist).
3. Most of the ACOL studies employing the basic five to seven variables, as well as unemployment, have very poor statistical performance.
4. Nonlinearity issues in the data, the model, and individuals' behavior *are not taken into account*. For example, if under an ACOL (20%) binary model, an increase in SRB by a unit (to all entitled personnel) results in a 1.1 ppt increase in reenlistment, the current models use this estimate to forecast the personnel behavior of an increase larger than one unit in SRB. Example: If the Navy wants to increase reenlistment (for a certain group, say Weapons Control) by 3.3 percent, then the current models suggest increasing SRB by 3 units to entitled personnel (e.g., 3 times 1.1). In doing so, these models do not take into account two major issues: nonlinearity in the functional form of the econometric model, and (more important) the *decreasing marginal effects* of the SRB. Taking these two effects into consideration will yield better estimates (even under the ACOL model).

5. Terminology. In the ACOL literature, the experiments are written as an increase in SRB by a unit to *all personnel*. This is misleading as the ACOL calculator "allows" an SRB (or SRB change) only for the entitled personnel by Navy criteria (e.g., LOS 2–14 years, Zones A–C, certain grades, only if an individual reenlists for at least 3 years, etc.).
6. In some cases the observed number of individuals receiving SRB payments is so small (approximately 1–1.5%), the experiment is based on practically irrelevant estimates, resulting in biased estimates.

However, it is emphasized that from a theoretical (economic theory) point of view the ACOL (or ACOL 2) models are correct and represent the right approach, but unfortunately, the data limitation stands in the way as discussed above.

Suggested Improvements Under the ACOL Type Models

1. Use at least 40 percent discount factor (probably more). Note that most of the individuals entitled to SRB are young and probably exhibit a very high discount factor. (See for example, Warner and Pleeter, 2001, who studied the personnel discount factor and found it to be in the range of 10–15% for officers and 35–54% for enlisted personnel. For more recent study see Harrison & Johnson, 2002.)
2. Build a table (per profession and/or subgroup) of the impact of SRB increases from 0.5 through 3 units.
3. Incorporate more macro level variables (as well as their lag values) such as unemployment rate, interest rate, and others (see for example the detailed GME non-ACOL model). However, it should be remembered that the ACOL models have very poor statistical performance (on average), therefore even adding more right hand side variables may not increase the explanatory power by much, yet it decreases the impact of the ACOL variable (see Tables and Figures).
4. Rather than just using the mean value of the reenlistment probability, present the whole range (or histogram).
5. Provide a range of estimates by contrasting both binary and multinomial results as well as different right hand side variables as well as different discount factors. This will provide the user with some more realistic bounds on prediction.

To summarize, suggestions 2 and 4 address presentation and applications of the results, while the others provide ideas for more sensitivity analyses within the traditional ACOL framework.

Suggested SRB Experiments under the Non-ACOL, Semi-Parametric GME Model

The non-ACOL Generalized Maximum Entropy (GME) model for MODCOMP was developed and presented in a technical report (Golan, 2003). Within that approach we can use the ACOL-type model or a non-ACOL model. In both cases the GME model is shown to be more efficient than the ML model in the sense that the GME estimates are more robust and more stable (lower variances) than those of the ML model, especially for smaller samples or samples with moderate or high level of collinearity. For the ACOL GME model, the SRB experiments are done exactly as under the ML approach and the recommendations given above hold.

We now discuss the SRB experiments for the non-ACOL GME model. But first, we emphasize that the reason for working with the non-ACOL GME is because of its better empirical performance as compared with the ACOL models. That is, for two models that are compared for their in-sample and out-of-sample performance and both are of the same level of complexity, we want to work with the better model. Under these statistical criteria the non-ACOL GME model is the better model for the data analyzed here.

Under the non-ACOL framework, the design of the SRB increase experiments is done in a different way than under the ACOL model. There are many ways of investigating the potential change in reenlistment as a result of a unit (or less/more) increase in the SRB. For example, one can increase SRB for all individuals, for the sub-group of potential entitled individuals, and by any other desired criterion. But also, one should take into account the estimated probability of reenlistment for each individual in the data set. Further, to accommodate for the nonlinearities issues discussed above, a detailed table (and figures) provides the SRB effects in increments of 0.5 units. The recommended experiment is the following.

Step 1. Estimate the non-ACOL GME model, *only for the entitled personnel* of the specific group of interest (e.g., individuals with Length of Service of 2 to 14 years, and grade in the range 3 through 7 or 8). Working with that sub-group ensures that there is no bias in our experiment.

Step 2. Increase SRB by no more than 0.5.

Step 3. Calculate the dollar amount of the SRB increase per individual in the analyzed subset.[1]

Since SRB payment is done in two basic steps: 50 percent upon reenlisting and the remainder throughout reenlisted period, we try to capture this by providing two bounds: one reflects 0 percent discount factor (meaning we use the whole 100% dollar value of SRB), and the other reflects infinitely high discount factor (meaning we count only the 50% that is received upon reenlistment). The truth is probably somewhere in between. These are done in Steps 3A and 3B.

<u>Step 3A</u>. The zero percent discount factor. Retain the value from Step 3.

<u>Step 3B.</u> The infinitely high discount factor. Multiply the value from Step 3 by 0.5.

[1] The formula used to convert the SRB multiples to real dollar terms is:
Real-Dollar = Length-of-Reenlist * SRB * (BasePay/12) where for lack of data, in all the models and results presented here, we used Length-of-Reenlist = 4.

Step 4. Multiply the above dollar amount (either 3A or 3B) by the estimated reenlistment probability (from Step 1 above) for that individual. (Note that in some cases the value calculated here may be lower than the original dollar SRB amount—in that case, the original dollar amount remains unchanged.)

Step 5. Using the estimated coefficients from Step 1, recalculate the reenlistment probability for each individual (with the new adjusted dollar SRB amount calculated in Step 4).

Step 6. Calculate the expected value (over individuals) of the resulting reenlistment probability. Comparing it with the reenlisted probability (Step 1) gives the percent change in reenlistment as a result of the SRB increase (for SRB = 0.5, 1, 1.5…) for the entitled (to SRB) subgroup analyzed.

Step 7. Finally, since the entitled to SRB subgroup is smaller than the whole profession analyzed (say 25,000 entitled to SRB out of 45,000 in the profession of interest) the reenlistment probabilities increments from Step 1–Step 6 should be normalized accordingly. These "normalized" values are the ppt increase we work with.

Step 8. Repeat Steps 1–7 for SRB = 1, 1.5, 2….

For the above experiment to hold and to be a correct procedure, it must be verified that

1. The dollar value of the increased SRB falls within the original bounds of that quantity. (In all experiments presented here, this requirement holds.)
2. The number of observed individuals receiving SRB in the sub-sample analyzed cannot be too small.

Finally, to see the real impact of the SRB experiments, it is suggested to look at the whole distribution of reenlistment and not just at the resulting expected values. That is, it is essential to look at the shift of the distribution as a result of the SRB increase. This will be demonstrated in the following examples.

Detailed Analyses of Four Navy Professions

In this section we use the above framework to investigate four different skill groups: Weapons Control, General Seamanship, Sensor Operations, and Administration. Since one of the main objectives in this work is to perform model and method comparison, for the Weapons Control and General Seamanship skill groups we provide a very detailed analysis. To keep the report from becoming too long, only the important findings for the Sensor Operations and Administration skill groups are presented. More detailed results are available upon request.

Weapons Control

We demonstrate our approach with the main results obtained for the Weapons Control group (1995–2002) consisting of 66,509 individuals. The independent variables used (in addition to the intercept) are Gender, Race, Number of Children, AFQT Score, Base Pay, Total Allowance, Education Dummies (No High School and Above High School), Sea Duty, Dollar Amount SRB, Zone Dummies, Expected Civilian Wage (Golan, 2003), Lag Real Interest Rate, Lag Value of NASDAQ index, and Unemployment Rate.

The tables and figures below present the results of the SRB experiments studied and developed here. Table 1 presents the basic results for the full sample. *The normalized values (lower and upper bounds as reflected by zero and infinitely high discount factors) are the values recommended for use.* Table 2 presents a comparison across different model scenarios: the binary and the 3-choice multinomial, as well as Zones A, B, and C for the infinitely high discount factor. The main results observed here are that (1) an analysis of small increments of SRB is more accurate since the ppt are not linear, (2) there is a major difference in ppt between a multinomial and binary models (that use the same right hand side variables), and (3) individuals in different zones behave differently.

Table 3 provides a detailed analysis of the traditional ACOL model (call it "Base") and the more detailed model (call it "Extended") that includes more information on both the individuals and the macro state of the economy. Both types of models are presented for the binary and 3-choice models and are based on the ML-Logit. (Probit analyses were done and yielded very similar results, so are not presented here.)

The main results here are that (1) the ppt increases as the discount factor increases, (2) the 3-choice model yields (on average) higher ppt than the binary models, (3) the basic model ("Base") yields higher ppt values than the more general model ("Extended"), and (4) that different subgroups (e.g., Zone A) behave differently.

Table 1
Weapons Control—SRB experiments for GME 3 categories model (full sample 66,509 observations)

	Implied Elasticities (0)	Prob Leave	Prob Extend	Prob Reenlist (infinity)	Prob Reenlist (0)	% Change Reenlist (infinity)	% Change Reenlist (0)	Mean $SRB	Normalized % Change Reenlist (infinity)	Additional Reenlisted Personnel	Normalized % Change Reenlist (0)	Total Cost of Policy $1,000	Cost of Policy per add'l enlisted $
Base Case		0.4615	0.2032		0.3353			1,244					
SRB + 0.5	0.45	0.4008	0.2118	0.3580	0.3875	6.8%	15.6%	1,677	6.3%	3,458	12.3%	To Add	To Add
SRB + 1	0.40	0.3554	0.2135	0.3842	0.4311	14.6%	28.6%	2,129	12.2%	7,715	23.0%	To Add	To Add
SRB + 1.5	0.36	0.3224	0.2115	0.4078	0.4661	21.6%	39.0%	2,582	17.7%	11,506	31.7%	To Add	To Add
SRB + 2	0.33	0.2982	0.2075	0.4289	0.4943	27.9%	47.4%	3,034	22.7%	14,964	38.8%	To Add	To Add
SRB + 2.5	0.30	0.2802	0.2025	0.4478	0.5173	33.6%	54.3%	3,486	27.3%	18,090	44.7%	To Add	To Add
SRB + 3	0.28	0.2664	0.1971	0.4647	0.5364	38.6%	60.0%	3,938	31.5%	20,817	49.5%	To Add	To Add

Table 2
Weapons Control—SRB experiments for GME binary and 3 categories and by Zones

	Normalized % Change Reenlist (infinity) 3-Choice	% Change Reenlist (infinity) Binary	% Change Reenlist (0) 3-Choice	% Change Reenlist (0) Binary	Normalized % Change Reenlist (0) 3-Choice	Normalized % Change Reenlist (0) Binary	Normalized % Change (infinity) Zone A 3-Choice	Normalized % Change (infinity) Zone B 3-Choice	Normalized % Change (infinity) Zone C 3-Choice
SRB + 0.5	6.3%	1.8%	15.6%	8.0%	12.3%	6.7%	4.7%	9.8%	24.6%
SRB + 1	12.2%	6.4%	28.6%	15.9%	23.0%	13.4%	9.3%	18.7%	44.8%
SRB + 1.5	17.7%	10.8%	39.0%	23.3%	31.7%	19.8%	13.8%	27.5%	60.6%
SRB + 2	22.7%	15.0%	47.4%	30.2%	38.8%	25.6%	18.2%	35.8%	72.8%
SRB + 2.5	27.3%	19.0%	54.3%	36.5%	44.7%	NA	22.3%	43.5%	82.3%
SRB + 3	31.5%	22.8%	60.0%	42.2%	49.5%	NA	26.3%	50.7%	89.7%

Table 3
Reenlistment percentage point increase for SRB increase of one unit for the basic and extended ACOL models: Weapons Controls (1995–2002): 66,509 observations

Basic						
Groups	**Binary**			**Three Choices**		
	10%	**20%**	**40%**	**10%**	**20%**	**40%**
Full Sample	0.4	1.2	3.9	0.9	2.3	4.9
1996	0.3	0.9	3.1	0.5	1.8	4.1
1997	0.5	1.5	4.6	1.2	3.1	6.0
1998	0.4	1.1	3.7	0.9	2.4	5.1
1999	0.4	1.3	4.2	0.9	2.2	4.9
2000	0.3	1.1	3.8	0.9	2.2	4.4
2001	0.4	1.2	4.0	1.0	2.4	4.8
2002	0.3	1.0	3.4	1.0	2.3	4.3
Zone A	6.3	10.3	11.5	5.9	9.9	11.5
Zone B	6.2	9.4	13.6			
TOS 4	6.5	13.7	22.0			
TOS 5	0.2	1.2	5.8			
TOS 6	0.3	1.0	3.5			

Extended						
Groups	**Binary**			**Three Choices**		
	10%	**20%**	**40%**	**10%**	**20%**	**40%**
Full Sample	0.3	1.1	3.4	0.3	1.2	3.6
1996	0.1	0.7	2.6	0.1	0.6	2.5
1997	0.3	1.1	3.7	0.3	1.3	4.0
1998	0.2	0.7	2.9	0.2	0.9	3.4
1999	0.4	1.2	3.8	0.4	1.5	4.2
2000	0.4	1.2	3.3	0.4	1.4	3.4
2001	0.4	1.3	3.5	0.5	1.7	3.9
2002	0.4	1.2	3.1	0.5	1.6	3.5
Zone A	4.3	7.3	8.6	4.2	7.3	8.6
Zone B						
TOS 4						
TOS 5						
TOS 6						

1. TOS is the Terms of service (4, 5, 6 years)
2. The Base Pay Elasticities are 0.2 (ACOL with 10% discount), and 0.4 for ACOL with 20% discount.

For the Weapons Control group the non-ACOL GME yields higher ppt for the full sample, but very similar results for the Zone A group.

Distributional Analysis

To see the real impact of the experiment, it is helpful to study the whole distribution rather than just the mean behavior as presented in the tables. This allows us to see the full shift of the distribution resulting from the SRB increase. Figure 1 presents the original reenlistment distribution (based on the estimated values) for the full Weapons Control data. An increase of *exactly one* SRB unit results in the new distribution (Figure 2). For each subgroup and case analyzed the relevant distributions are studied. The next set of figures demonstrates the different underlying distributions for some chosen sub-groups.

To keep this report to a reasonable length, we do not present the distributional shifts for all cases analyzed. However, the computer code generates these distributions as part of the analysis.

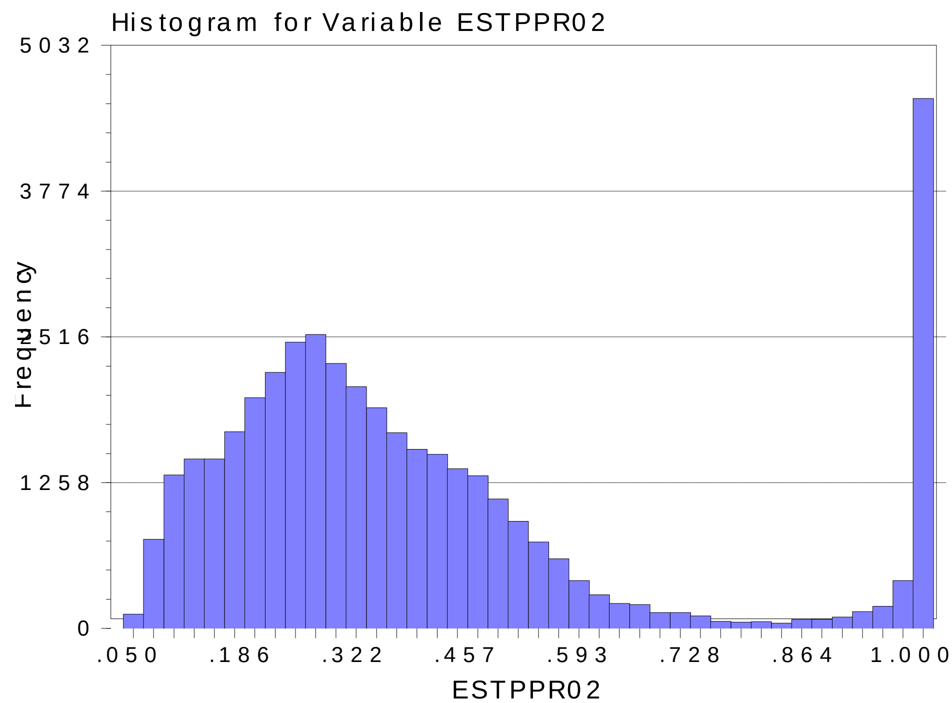

Figure 1. Weapons Control: all sample—original reenlistment distribution from the GME (3 choice model)—entitled personnel.

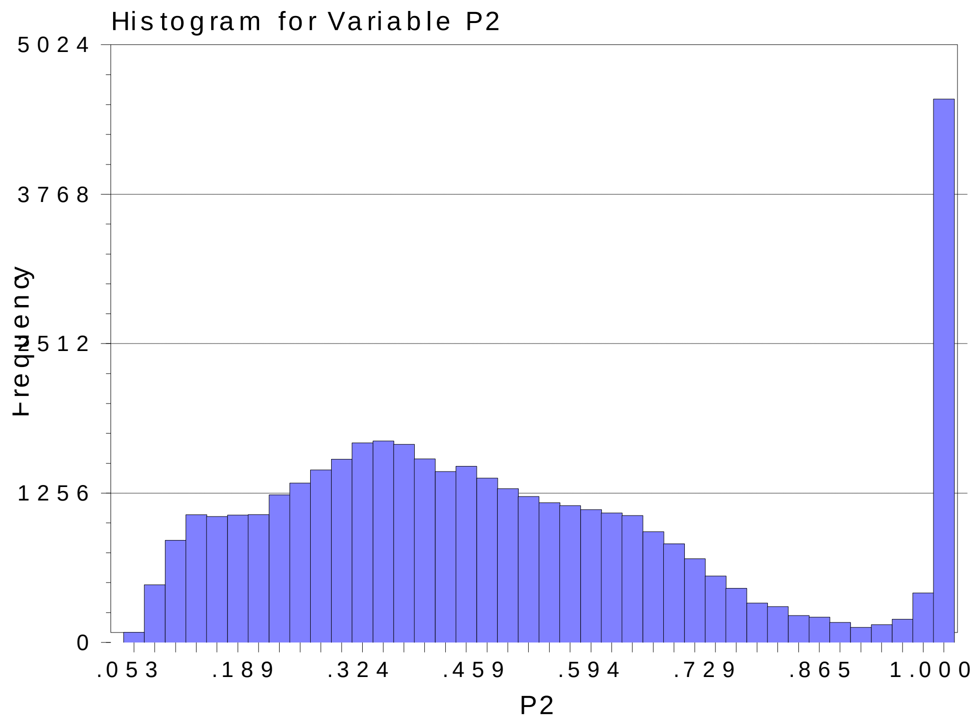

Figure 2. The new reenlisted distribution resulting from a one-unit increase in SRB-entitled personnel.

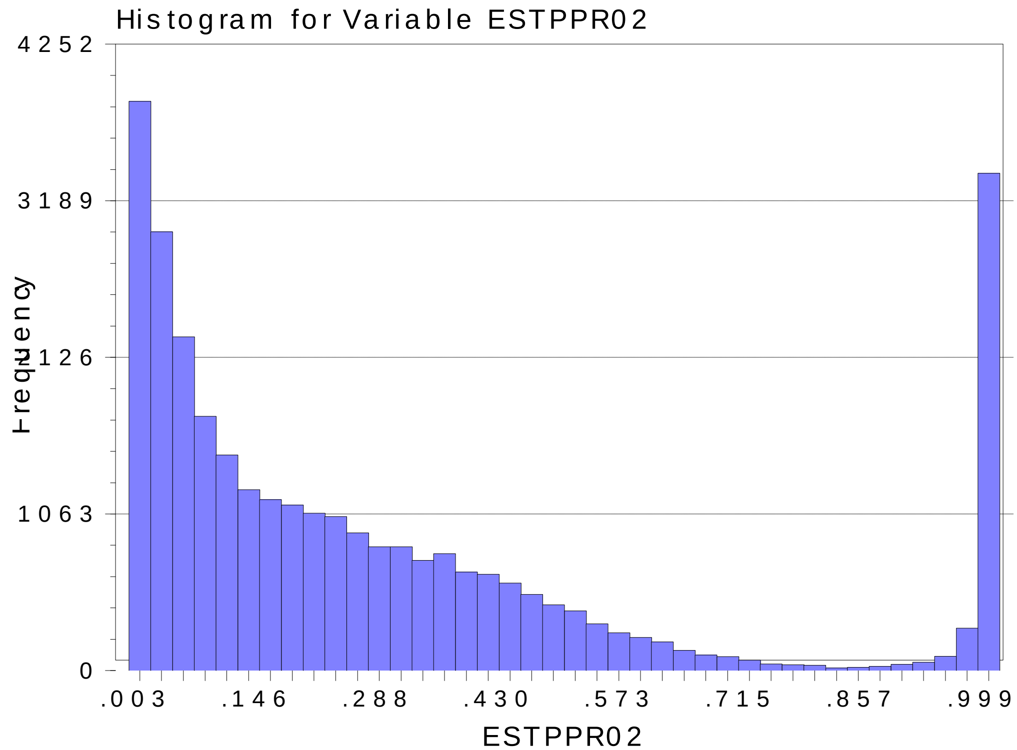

Figure 3. Weapons Control–Zone A—original reenlistment distribution from the GME (3-choice model).

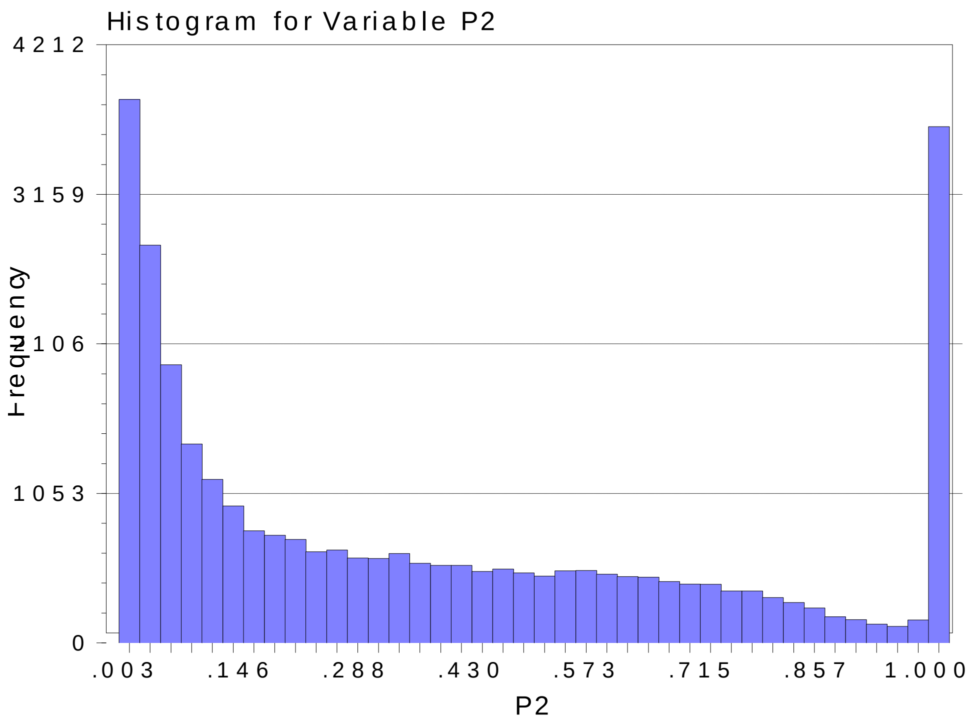

Figure 4. Zone A—The new reenlisted distribution resulting from a 1-unit SRB increase.

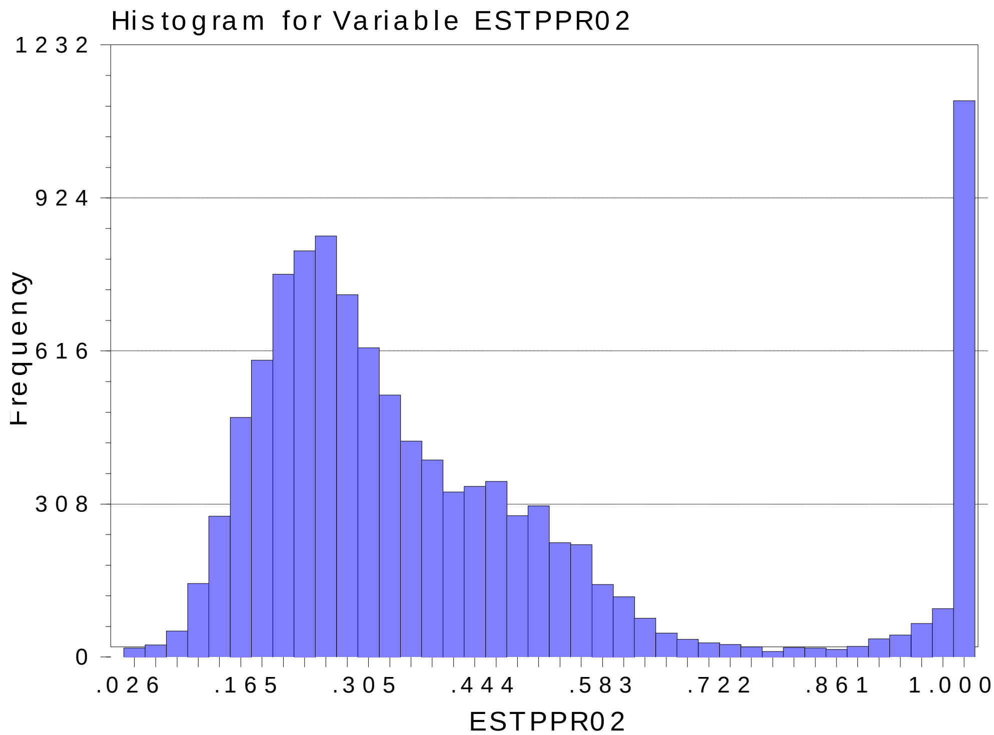

Figure 5. Weapons Control–Zone B—original reenlistment distribution from the GME (3-choice model).

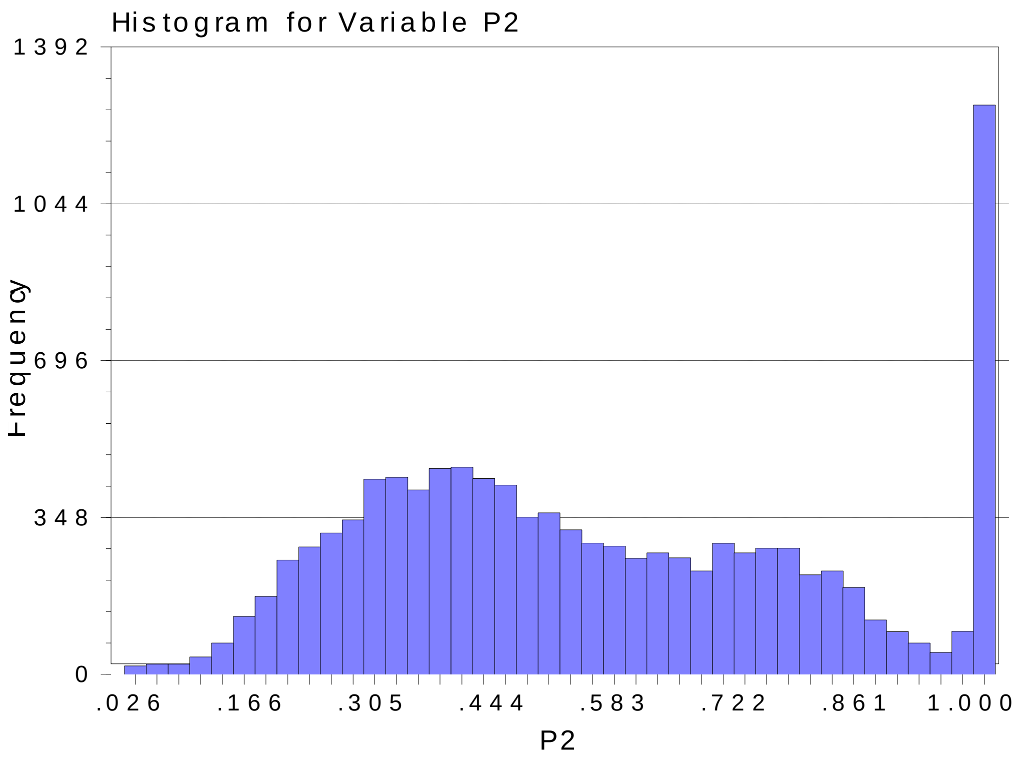

Figure 6. Zone B—The new reenlisted distribution resulting from a 1-unit SRB increase.

Main Results–Graphical Presentation

The following set of Figures presents our basic findings.

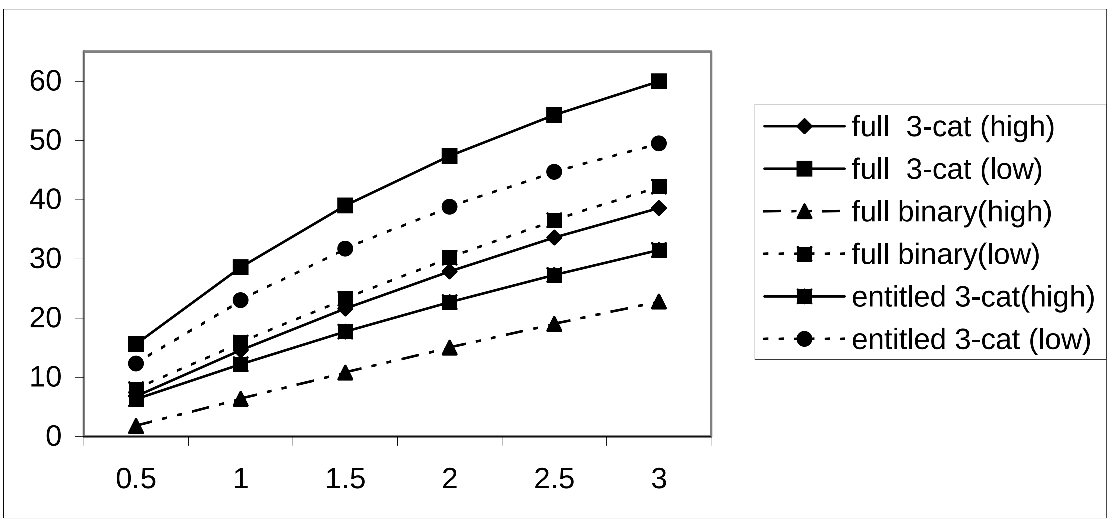

Figure 7. Reenlistment ppt increase for Weapons Control—GME non-ACOL. Comparison of full sample and the adjusted normalized entitled subsample, binary, and 3-category cases.

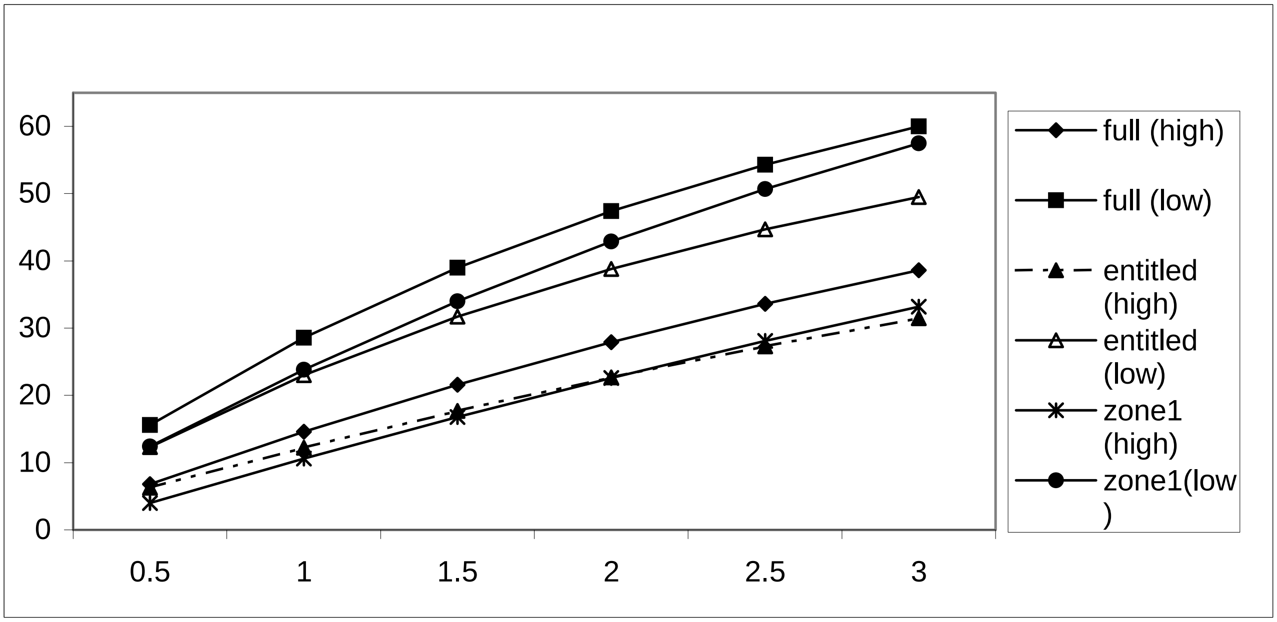

Figure 8. Comparison of full, normalized entitled, and Zone A (Zone 1) sub-samples of Weapons Control reenlistment ppt increase for high and low time preference, non-ACOL, 3–category case.

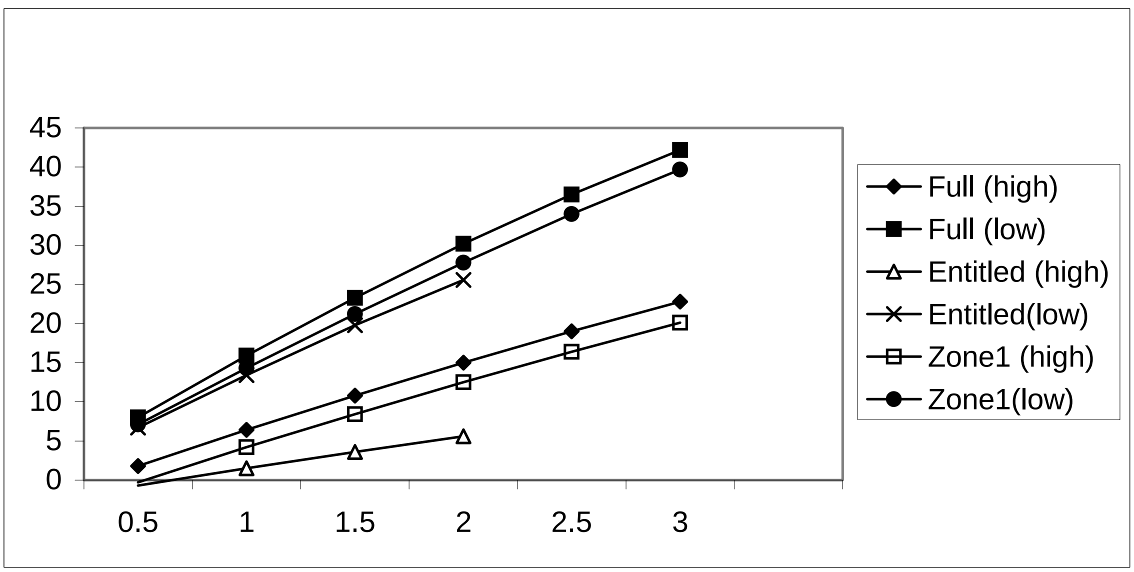

Figure 9. A Comparison between full, entitled, and Zone A samples of reenlistment ppt increase for Weapons Control with high and low time preference, non-ACOL, binary experiment.

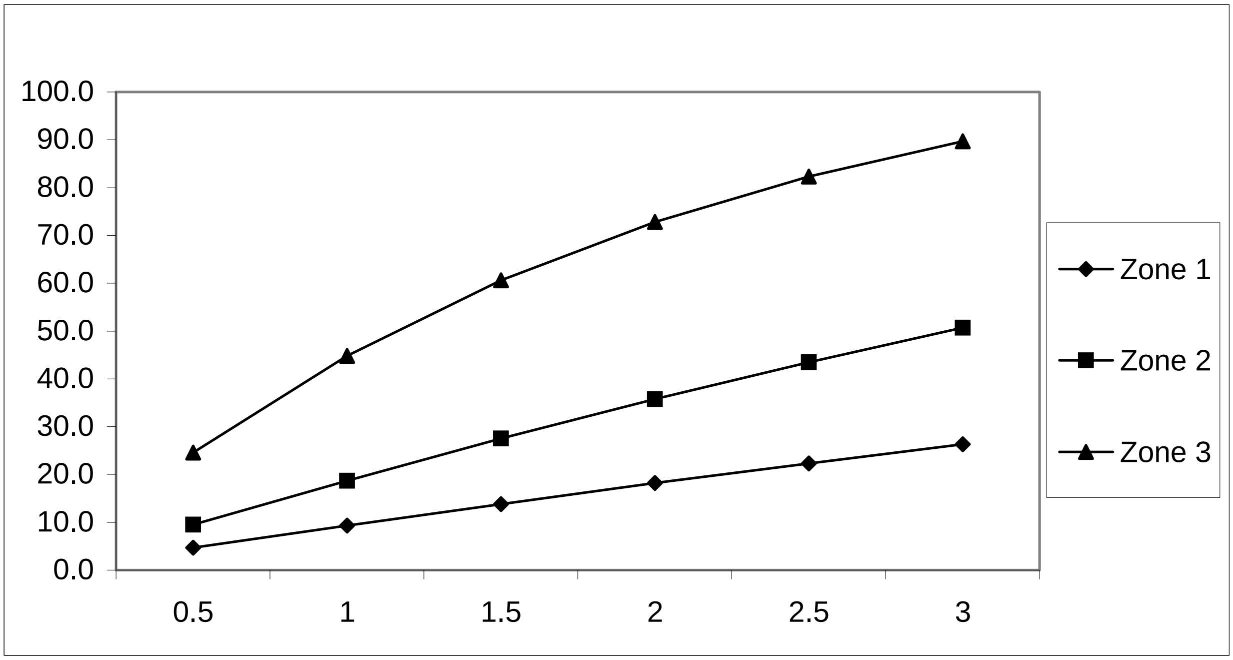

Figure 10. A comparison of the normalized entitled Zone subgroups for reenlist ppt Increase with high time preference, non-ACOL, 3 categories.

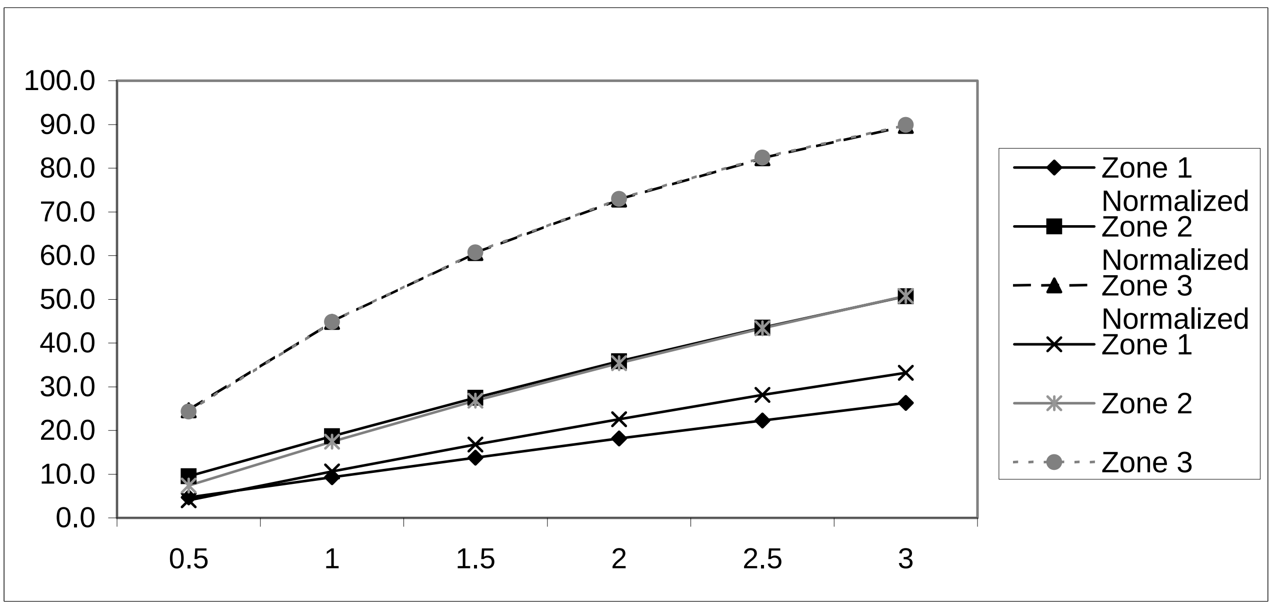

Figure 11. A comparison between full and entitled Zone subgroups with high time preference, 3-category model.

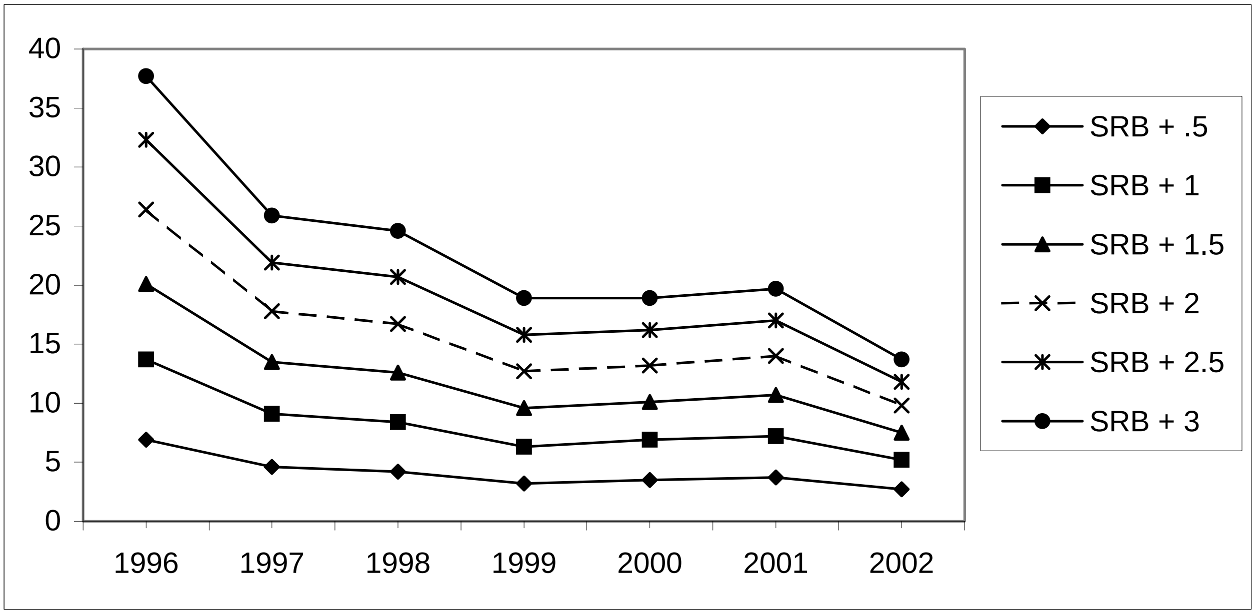

Figure 12. Trend in reenlistment for high time preference from 1996–2002, for SRB Increases from .5 to 3, non-ACOL, 3-categories model (based on normalized entitled group).

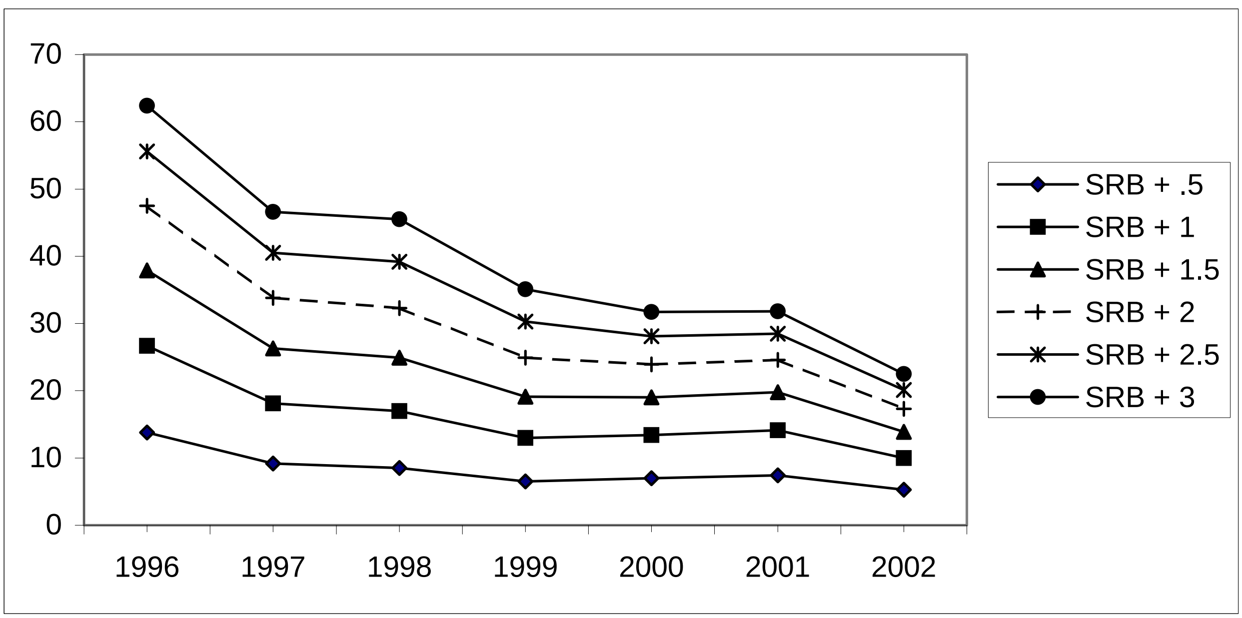

Figure 13. Reenlistment for low time preference from 1996–2002, non-ACOL, 3 categories (based on normalized entitled group).

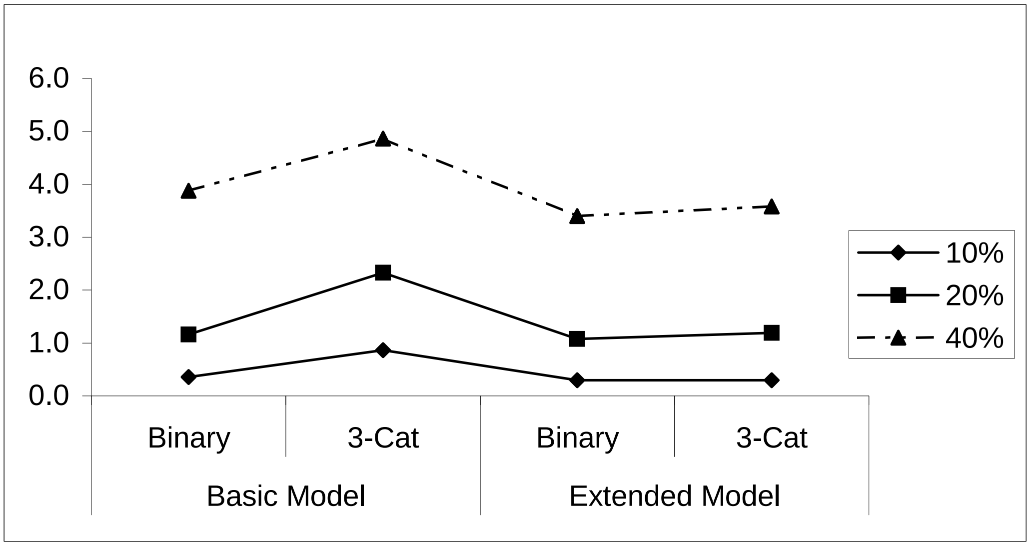

Figure 14. Reenlist percentage point increase, full sample, the ACOL models.

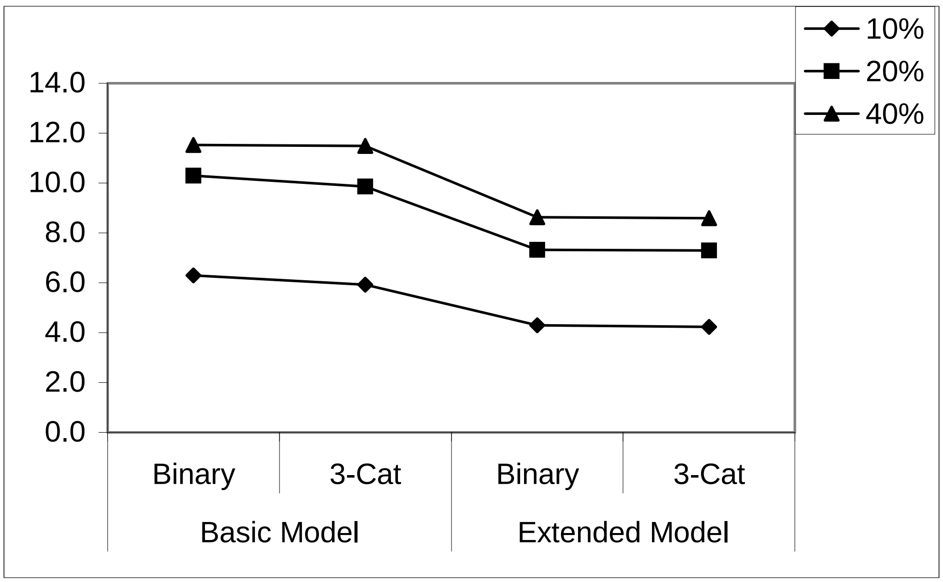

Figure 15. Reenlistment percentage point increase, Zone A, ACOL models.

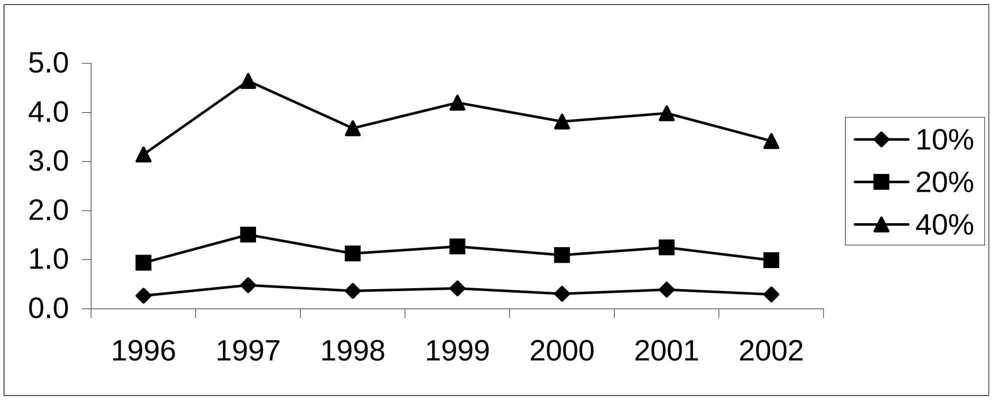

Figure 16. ACOL model trend in reenlistment from 1996–2002, for 10, 20, and 40 percent discount factors—basic ML binary model.

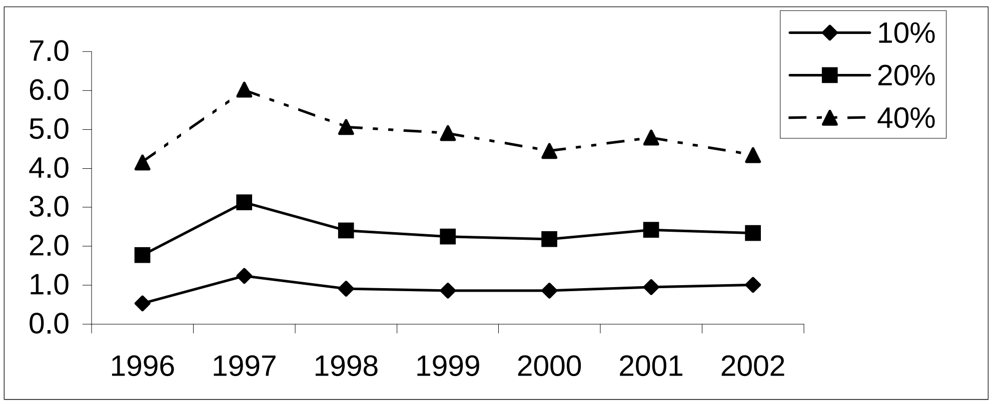

Figure 17. Trend in reenlistment from 1996–2002 - ACOL 10, 20, and 40 percent discount factors, basic ML 3-categories model.

Finally we present the (traditional) basic elasticities (averaged over individuals) for the different pay components.

Table 4
Weapons Control—basic statistics and elasticities (averaged over individuals) of reenlisted with respect to the pay components for entitled sample by year and by Zone

		All Years	1996	1997	1998	1999	2000	2001	2002	Zone 1	Zone 2	Zone 3
Base Pay	**Mean**	10876	11003	10970	10937	10694	10660	10793	9642	11812	13571	10847
	Elasticity	0.537	1.3396	1.4026	1.1219	-0.3524	-0.4363	0.0544	******	1.3401	0.00057	0.4682
Allowance	**Mean**	5699	5795	5771	5742	5599	5538	5584	5258	6097	6561	5691
	Elasticity	1.1664	1.5322	0.9690	1.4379	1.4864	0.8202	0.4291	1.521	0.9833	-0.00018	1.2165
$ Bonus	**Mean**	2048	1107	1331	1536	2970	3376	3345	2640	1858	342	2538
	Elasticity	0.0088	0.0086	0.0102	0.0113	0.008	0.0094	0.0123	0.0089	0.0122	0.00193	0.0113
Pseudo-R^2		0.25755	0.2284	0.2395	0.26142	0.2578	0.3110	0.32772	0.36806	0.3457	0.19528	0.13164
% Correct Prediction		62	60	62	65	63	65	67	68	69	57	53
# obs	**Entitled**	40381	8265	7047	5307	5546	5361	2561	22903	10713	6765	4783
	Full	66509	12861	11228	8646	9299	9244	4415	30755	10767	6923	8331

This concludes the detailed analysis of the Weapons Control group. More analysis and results are available upon request. Next, a way of understanding the SRB effects for cases with very small percentages of observed non-zero SRBs in the data are demonstrated.

General Seamanship

There are 54,790 observations with 27,028 entitled to SRBs if SRBs are given. However, only about 1 percent of the observed individuals received SRB in the past and the observed SRB is in the range 0.5 through 2.5. That means that any simple experiment, via the ACOL or non-ACOL methods, may yield highly biased results. After all, we cannot expect an experiment to be based on highly unobserved behavior. A number of approaches can be taken. First, we can aggregate the professions and just use dummy variables to indicate professions, and then run the experiments as before. However, in doing so, we miss the profession and group specific behavior, an approach that is not favored by the policy maker. The second approach is simply to extrapolate from other "similar" types of professions. The third approach is, rather than running the experiments as before, one analyzes the individuals' behavior toward their total wage and the SRB directly by investigating the estimates. This is the approach taken here. The independent variables used (in addition to the intercept) are Gender, Race, Marital Status, Number of Children, AFQT Score, Base Pay, Total Allowance, Education Dummies (No High School and Above High School), See Duty, Dollar Amount SRB, Zone Dummies, Civilian Wage (Golan, 2003), Terms of Service (TOS) dummy, Lag Value of NASDAQ index, and the Unemployment Rate. We now present this approach via a set of figures. All figures are based on the non-ACOL GME model used with three choices (leave, extend, reenlist).

These figures show very clearly that (1) SRB has a high impact on reenlistment behavior for the General Seamanship group, (2) reenlistment is highly related to the individuals' total wage but mostly to the SRBs, and (3) the above relationships are highly nonlinear (decreasing marginal effects). Given these figures that are based on the estimates, a nonlinear function relating the reenlistment increments to the increase in SRB or the increase in the dollar value of SRB can easily be accomplished via traditional regression of the estimated reenlistment probabilities on transformations of the SRBs, total wage, etc. This, in turn, will yield a whole table (or continuum) of marginal impacts of SRB on reenlistment.

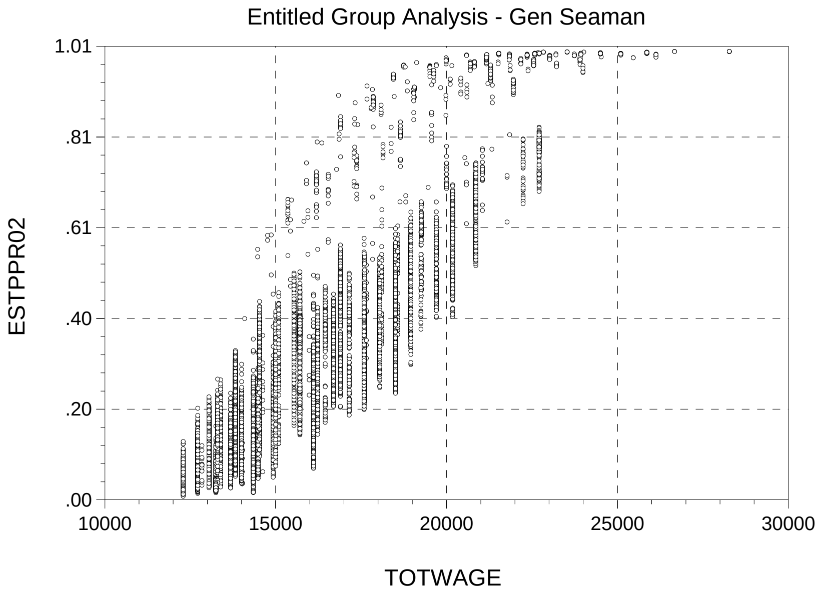

Figure 18. Estimated reenlistment probability (Estppr02) as a function of total wage (base pay + total allowances + dollar value of SRB).

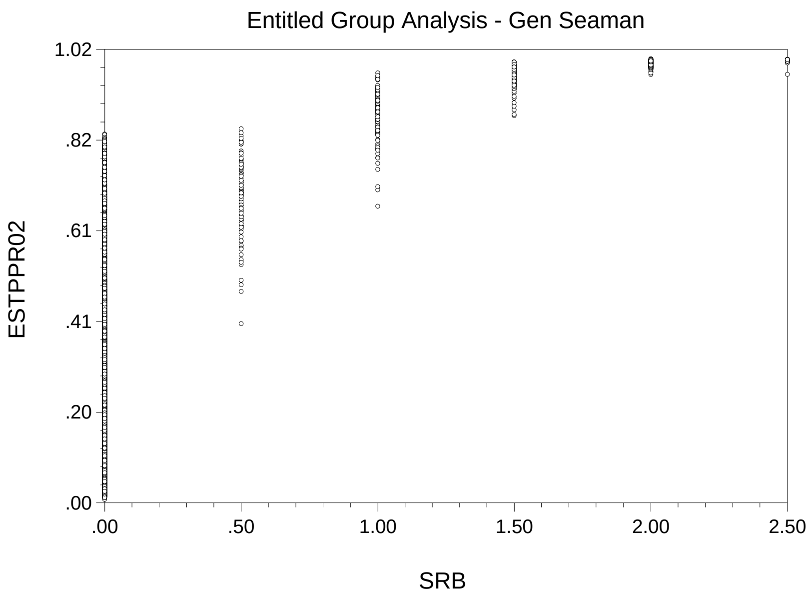

Figure 19. Estimated reenlistment probability as a function of SRB.

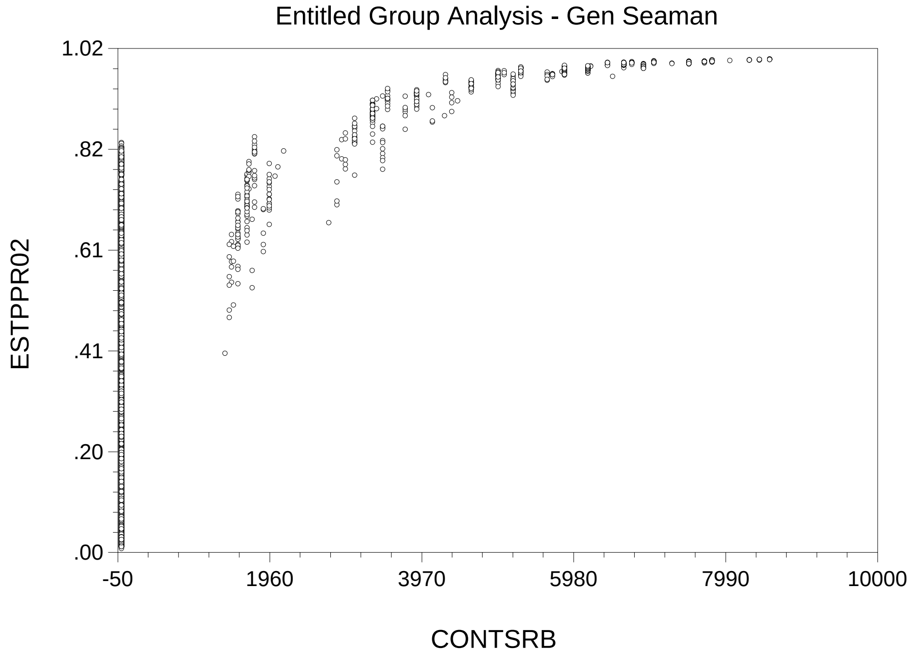

Figure 20. Estimated reenlistment probability as a function of dollar value of SRB.

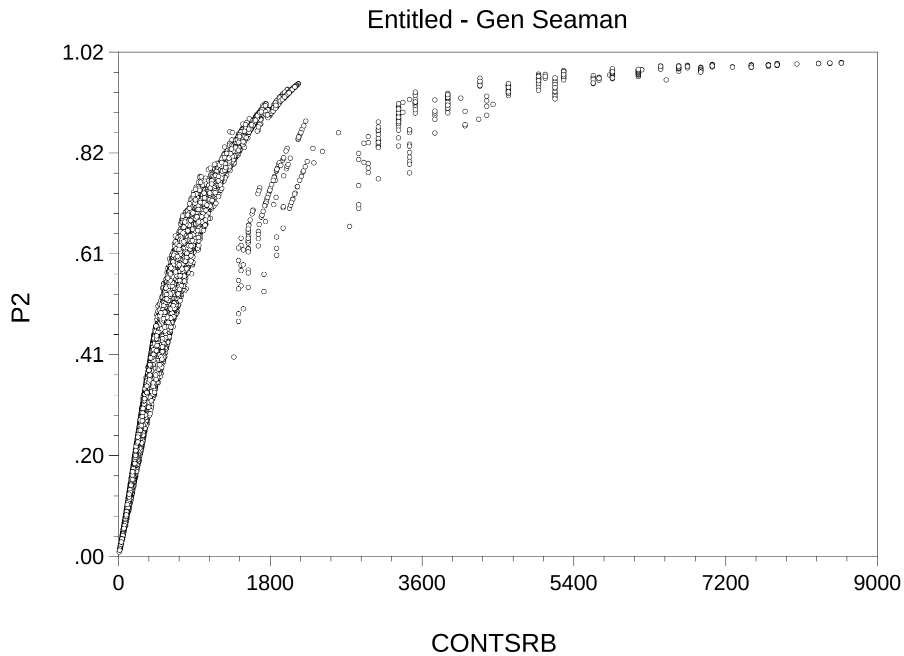

Figure 21. Theoretical *reenlistment* probability as a function of dollar value of SRB resulting from a unit increase of SRB to entitled personnel.

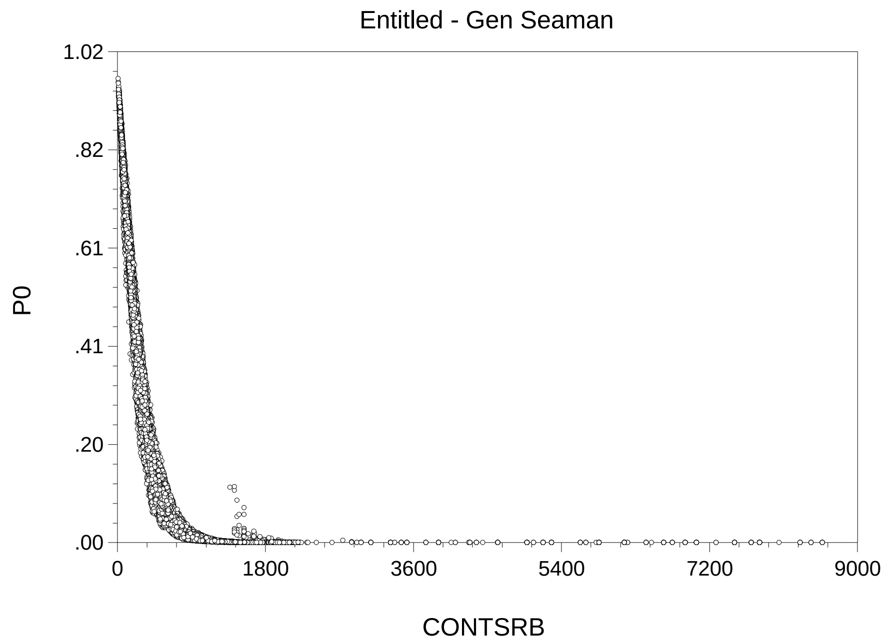

Figure 22. Theoretical *leave* probability as a function of dollar value of SRB resulting from a unit increase of SRB to entitled personnel.

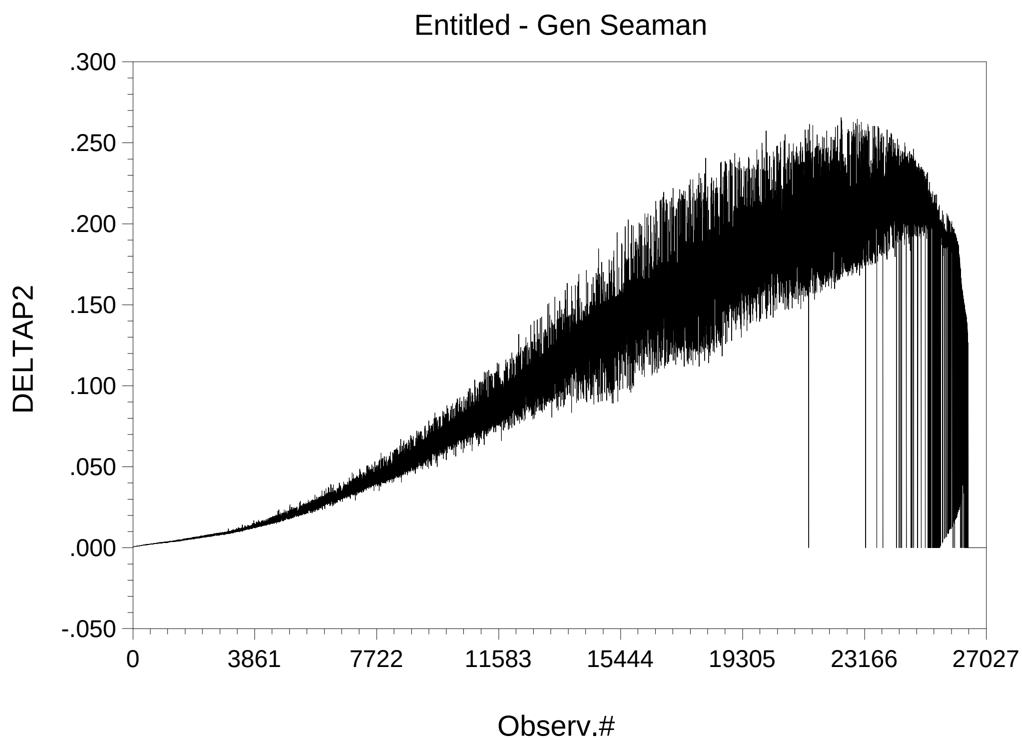

Figure 23. Theoretical *difference in reenlistment* probability as a result of increasing SRB by a unit.

Next, the ML-ACOL analysis is presented.

Table 5
Elasticities of the basic binary ACOL model—General Seamanship (1995–2002: 54,790 observations)

Discount	20%		10%		20%	10%
Bonus	SRB All	SRB-Entitled	SRB All	SRB-Entitled	Base Pay	Base Pay
Full Data	1.5		0.5		0.5	0.33
TOS = 4	1.47		0.5		0.5	0.33
TOS = 5	0.13		0		0.08	0
1995	0.6		0.2		0.2	0.2
1996	1.5		0.5		0.4	0.3
1997	1.9		0.6		0.6	0.4
1998	1.2	0	0.4	0	0.4	0.3
1999	1.2	0	0.4	0	0.4	0.3
2000	1.8	0.1	0.6	0	0.8	0.5
2001	1.3	0	0.4	0	0.5	0.4
2002	1.1	0	0.4	0	0.5	0.4
Zone A (36,994 obs.)	33.0	1.1	19.5	1.1	6.3	8.4
Extended—Zone A	27.2		16.8		4.9	6.7
1996—Zone A (8,603 obs.)	30.5	1.8	17.5	1.2	6.3	8.1
2000—Zone A (4,783 obs.)	32.9	2.4	19.9	1.4	6.7	9.07.9
2001—Zone A (3,920 obs.)	28	1.7	17.2	1.0	6.0	
3-Categories Non-ACOL GME					1.9	

Notes: 1. Traditional ACOL analyses of Zones B and above, yield R-Squared of zero.
2. Years 1998, 1999, 2001 and 2002 have very low R-Squared.
3. SRB-Entitled represents the case where only those who received SRB in prior period(s) received a unit increase (an unrealistic case).

The next Table presents the (traditional) elasticities resulting from the non-ACOL GME estimates.

Table 6
General Seamanship—basic statistics and elasticities (averaged over individuals) of reenlisted with respect to the pay components for entitled sample

		All Years	Zone 1	Zone 2
Base Pay	**Mean**	9974	8902	11181
	Elasticity	5.2349	6.6827	-0.3291
Allowance	**Mean**	5350	4961	5846
	Elasticity	0.4466	0.8858	-0.1337
$ Bonus	**Mean**	135	127	258
	Elasticity	0.0047	0.0043	0.0096
Pseudo-R^2		0.21498	0.26475	0.11793
% Correct Prediction		60	64	51
# obs	**Entitled**	27026	17545	5543
	Full	54790	36994	5622

Sensor Operations

There are 20,512 observations with 12,923 entitled to SRBs if SRBs are given. This is "classic" data to analyze and perform experiments (as discussed earlier) since there is a high percentage of individuals who received SRB in the past. The independent variables used (in addition to the intercept) are Gender, Race, Number of Children, AFQT Score, Base Pay, Total Allowance, Sea Duty, Dollar Amount SRB, Zone Dummies, Expected Civilian Wage (see Golan, 2003), and the Lag Value of NASDAQ index. The following figures show the main results.

These figures show very clearly that (1) SRB has a high impact on reenlistment behavior for the Sensor Operation group, (2) reenlistment is highly related to the individuals' total wage but mostly to the SRBs, (3) the above relationships are highly nonlinear (decreasing marginal effects), (4) the non-ACOL and ACOL models yield very similar estimates (for SRB+1 case which is the only ACOL experiments done here), (5) the 3-choice model yields higher estimates for both types of models, and (6) the "Base" ACOL model yields higher ppts than the "Extended" ACOL model.

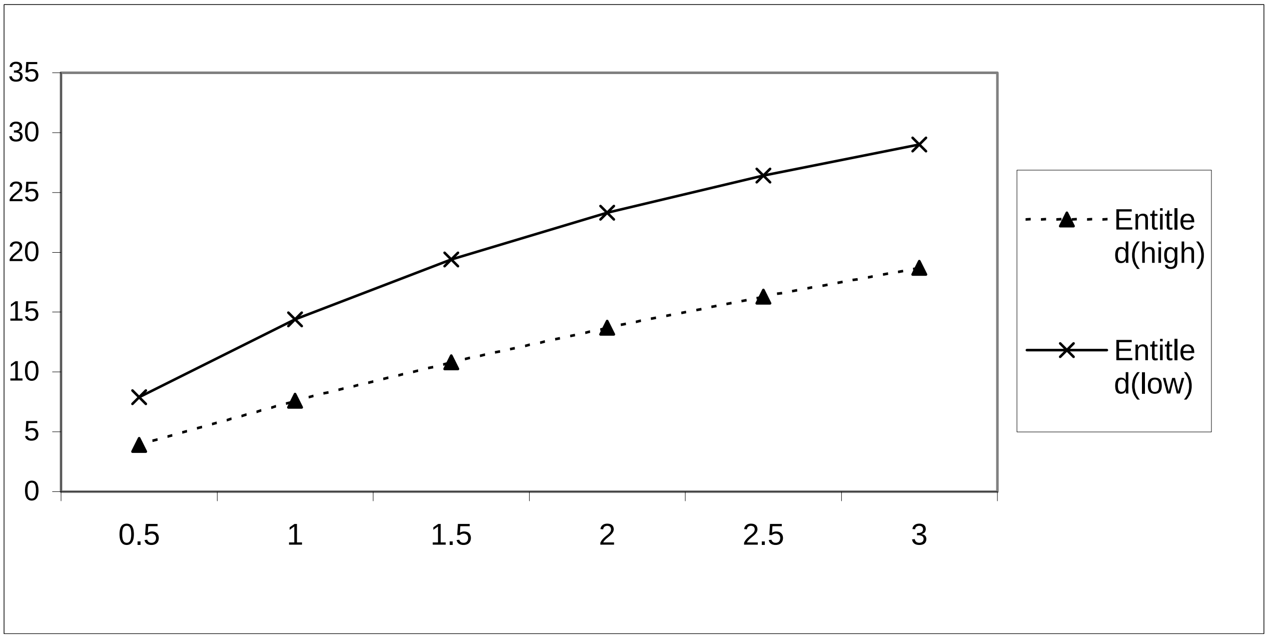

Figure 24. Sensor Operations—a comparison of reenlistment ppt increase for entitled samples with high and low time preference, non-ACOL, 3-category experiment.

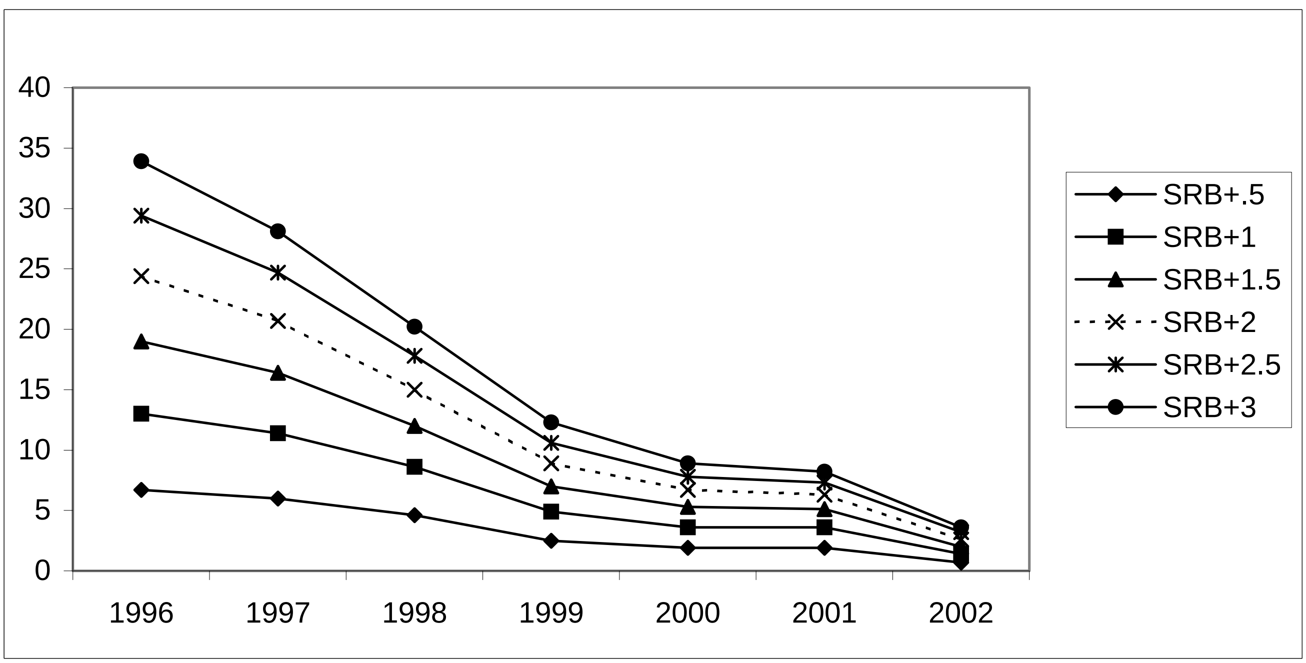

Figure 25. Sensor Operations—trend in reenlistment for high time preference normalized entitled group from 1996–2002, for SRB increases from .5 to 3, non-ACOL, 3 categories model.

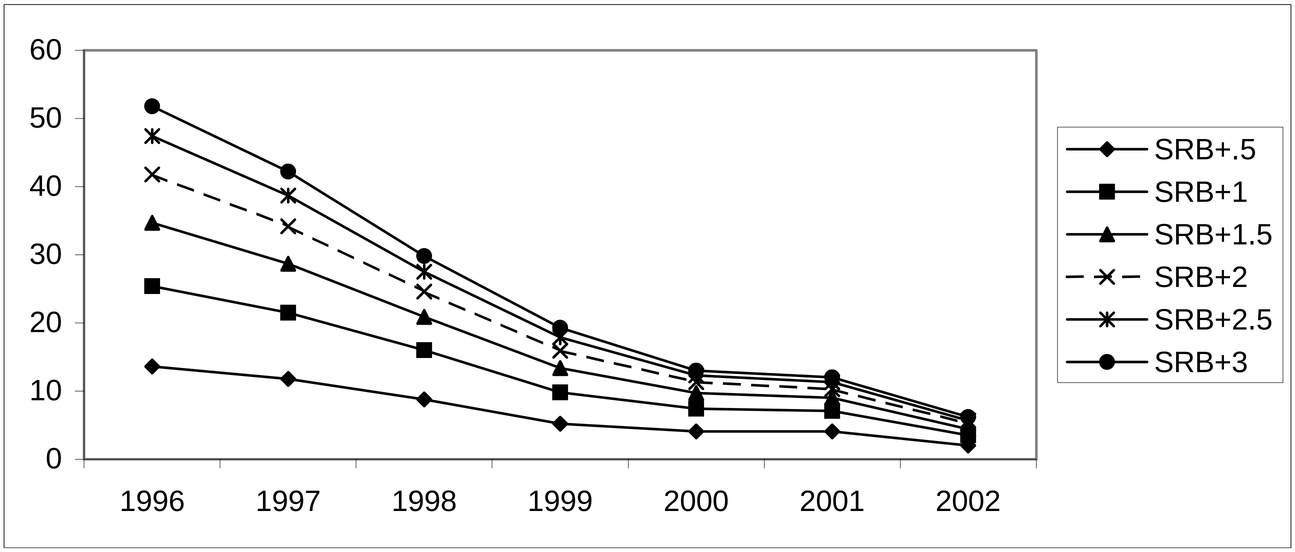

Figure 26. Sensor Operations—trend in reenlistment for low time preference normalized entitled group, 1996–2002, for SRB increases from .5 to 3, non-ACOL 3-categories model.

The next set of figures presents the relationship between reenlistment and the different pay methods (similar to the General Seamanship presentation).

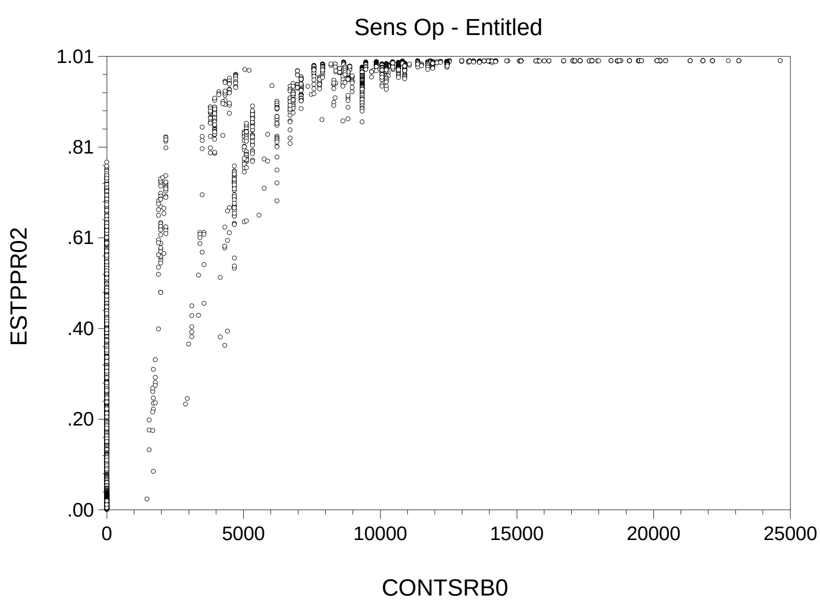

Figure 27. Estimated reenlistment probability vs. original dollar value of SRB.

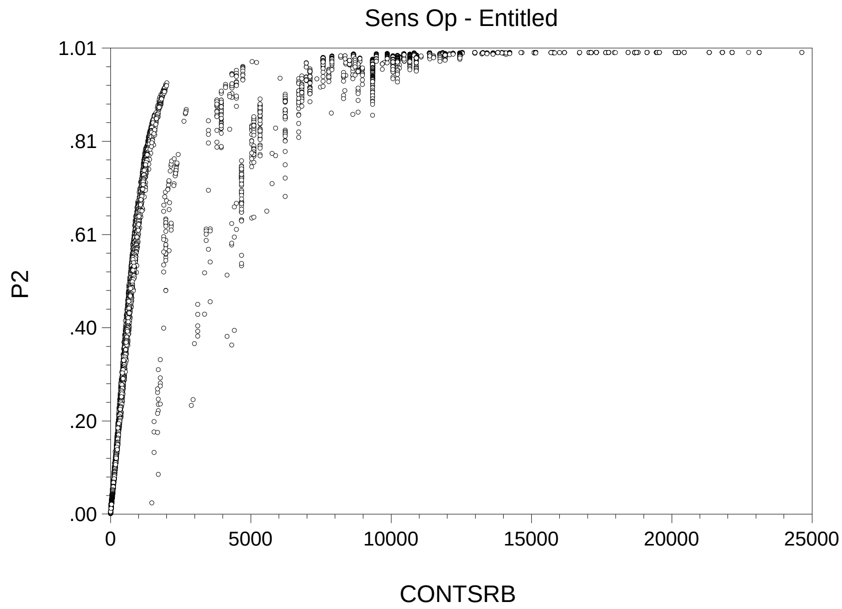

Figure 28. Estimated reenlistment probability vs. dollar value of SRB for the SRB experiment of a unit increase.

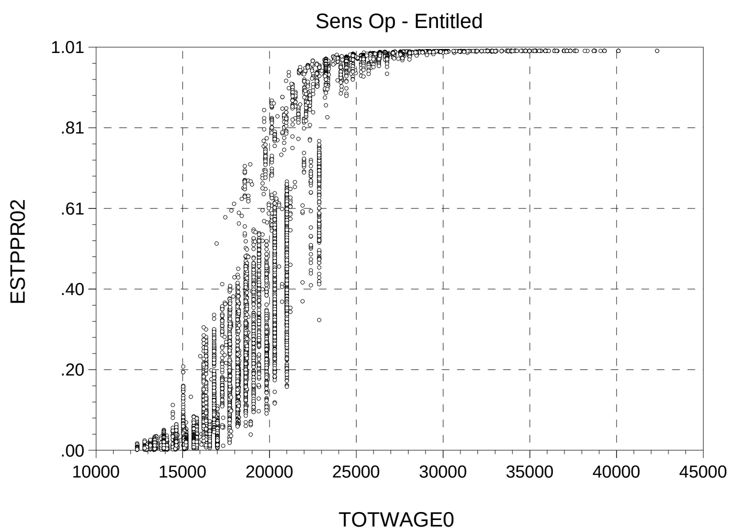

Figure 29. Reenlistment probabilities vs. original total wage (base pay + allowances + SRB).

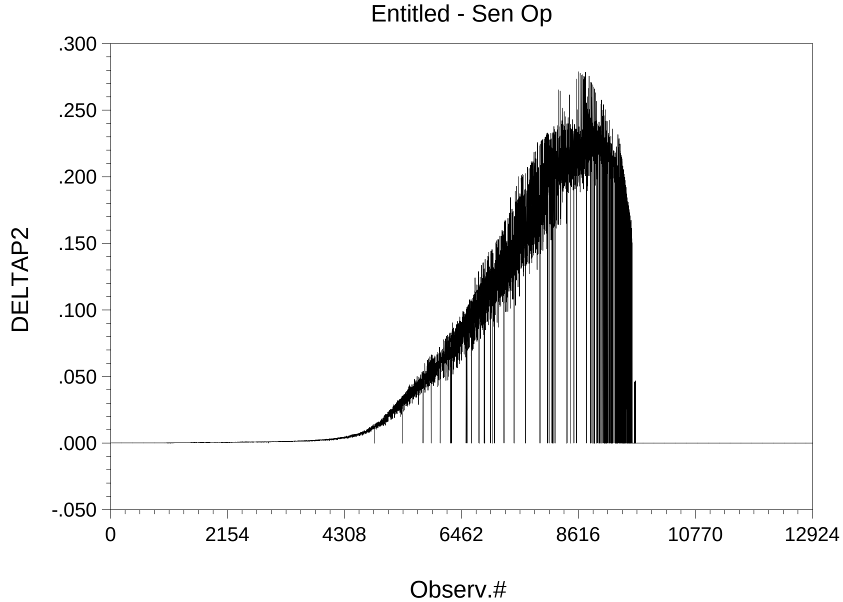

Figure 30. Difference between reenlistment probabilities and original estimates after increasing SRB by one unit for entitled personnel.

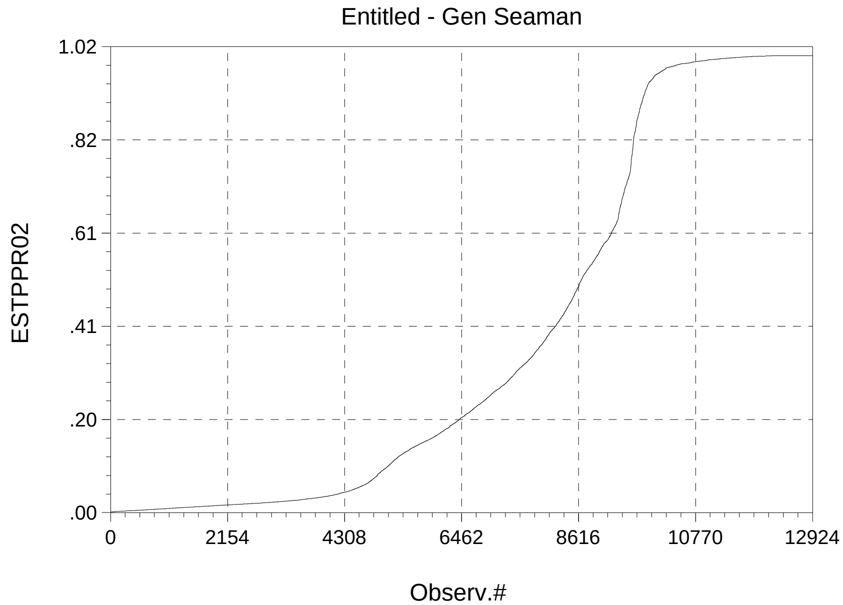

Figure 31. The full distribution (lowest to highest) of reenlisted probabilities resulting from the GME non-ACOL model.

Next, we present the (traditional) basic elasticities (averaged over individuals) for the different pay components.

Table 7
Sensor Operations—basic statistics and elasticities (averaged over individuals) of reenlisted with respect to the pay components for entitled sample

		All Years	Zone 1	Zone 2	Zone 3
Base Pay	**Mean**	10916	9628	11773	13467
	Elasticity	2.9322	2.2702	3.0949	3.0469
Allowance	**Mean**	5674	5195	6078	6515
	Elasticity	0.6431	2.1161	0.4327	0.1828
$ Bonus	**Mean**	3059	3911	3538	48
	Elasticity	0.0388	0.0552	0.0544	0.0014
Pseudo-R^2		0.45301	0.63612	0.3577	0.09894
% Correct Prediction		73	85	67	50
# obs	**Entitled**	12923	7166	3219	2538
	Full	20512	7988	3232	2632

Below are some of the ML ACOL SRB experiments.

Table 8
Elasticities of the basic binary ACOL model: Sensor Operations (1995–2002; 20,512 observations)

Discount	Bonus	Full Data	TOS=4	1997	Zone A (7988 obs.)	Zone B (3232 obs.)
20%	**SRB-All**	1.3	2.2	1.6	29.7	18.3
	SRB-Entitled	0.3	0.3	0.3	9.7	5.7
10%	**SRB-All**	0.3	0.2	0.5	18.9	10.2
	SRB-Entitled	0	0		6.9	3.4
20%	**Base Pay**	0.4	0.3	0.5	5.2	3.3
10%	**Base Pay**	0.2	0.1	0.3	7.0	3.6

Administration

For the Administration group, the analysis is similar to the General Seamanship group. Therefore, in order to save space, only very basic results are presented here. For the non-ACOL GME, the independent variables used (in addition to the intercept) are Gender, Race, Marital Status, Number of Children, AFQT Score, Base Pay, Total Allowance, Sea Duty, Education Dummies (No High School; High School Plus), Dollar Amount SRB, Zone Dummies, Civilian Wage (Golan, 2003), and the Lag Value of the NASDAQ index. The ML ACOL results are summarized in Table 9.

Table 9
Elasticities of the basic binary ACOL model—Administration (52,868 observations)

Discount Bonus	20% SRB-All	10% SRB-All	20% Base Pay	10% Base Pay
Full Data	0.8	0.3	0.3	0.2
1995	N/A	N/A		
1996	0.7	0.3	0.2	0.1
1997	0.9	0.3	0.3	0.2
1998	0.7	0.2	0.2	0.1
1999	0.9	0.3	0.3	0.2
2000	0.9	0.3	0.3	0.2
2001	0.8	0.3	0.3	0.2
2002	0.5	0.2	0.2	0.1
Zone A (17,330 obs.)	6.0	4.5	1.1	1.7
Extended Zone A	7.4	5.5	1.3	2.0

The estimates from the non-ACOL GME and their resulting traditional elasticities (evaluated at the mean over individuals) are presented below.

Table 10
Administration—elasticities (averaged over individuals) of reenlisted with respect to the pay components for entitled sample by year and by Zone

		All Years	1998	1999	2000	2001	2002	Zone 1	Zone 2	Zone 3
Base Pay	**Mean**	11,127	11,128	11,171	11,328	11,310	11,392	9,694	11,578	13,531
	Elasticity	2.2798	2.7001	2.2557	1.3102	0.7557	1.6054	4.6005	1.9386	0.4831
Allowance	**Mean**	5,768	5,776	5,794	5,803	5,771	5,841	5,280	5,991	6,501
	Elasticity	0.5347	0.5487	0.1329	0.4902	0.4634	0.5039	-0.0592	0.5954	0.4075
$ Bonus	**Mean**	56	11	46	132	212	83	65	30	70
	Elasticity	0.003	0.0014	0.0032	0.0093	0.0076	0.0057	0.0043	0.0013	0.0027
Pseudo-R^2		0.11045	0.10129	0.10627	0.11847	0.13849	0.15503	0.10373	0.09261	0.16404
% Correct Prediction		49	48	49	49	50	52	50	47	50
# obs	**Entitled**	34,107	5,435	4,959	4,390	4,094	2,002	16,308	9,936	7,863
	Full	52,868	8,297	7,796	7,213	6,887	3,365	17,330	10,001	8,082

Comparison Across Professions

Figures 32 and 33 represent a detailed comparison of the four groups studied. The ACOL model comparisons are shown first, followed by the non-ACOL GME experiments for Weapons Control and Sensor Operations.

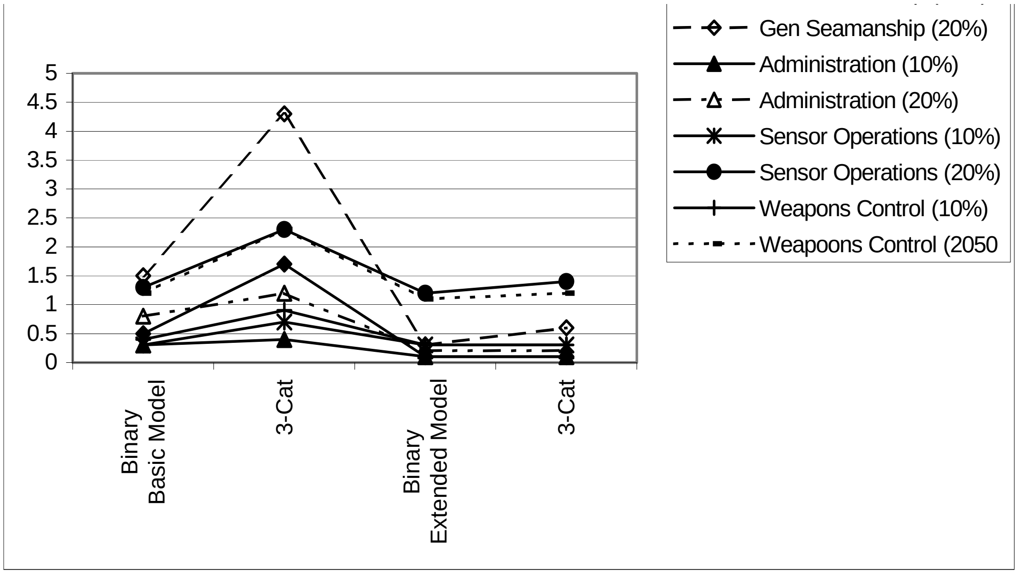

Figure 32. Comparison of ACOL model across professions—binary and 3-categories, basic, and extended ML.

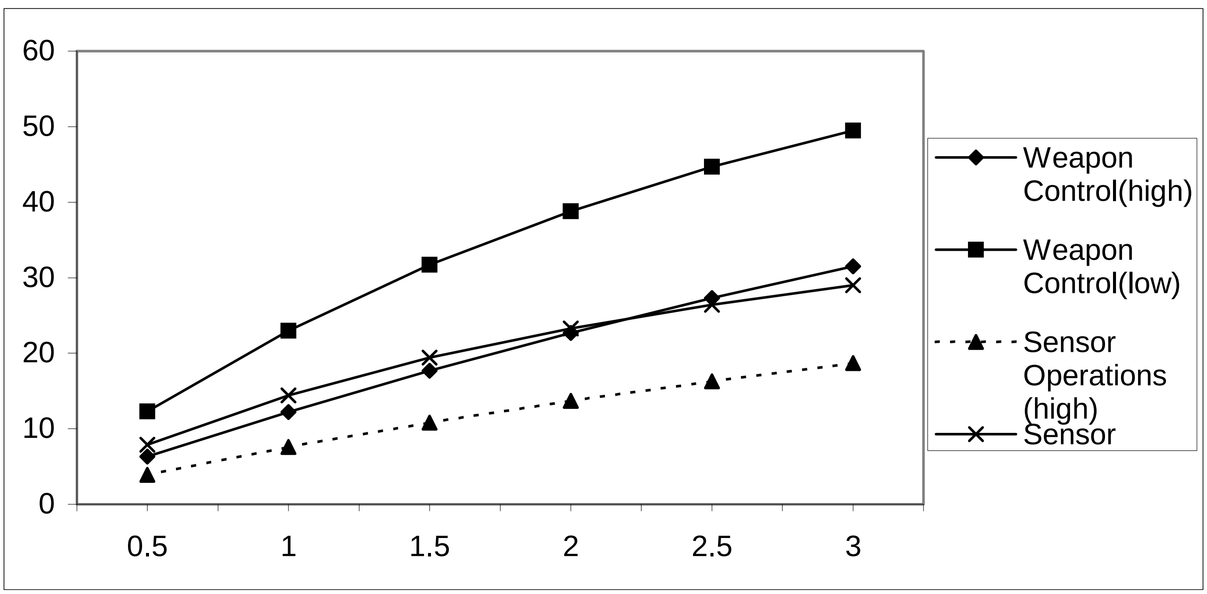

Figure 33. Comparison of the reenlistment ppt increase between Weapons Control and Sensor Operations for the Adjusted normalized entitled samples, non-ACOL 3-category experiment with high and low time preference.

Model Comparison

This section provides a detailed comparison of different models (ACOL and non-ACOL as well as different ACOL models). We start with very detailed of out-of-sample SRB experiments, using real data prior to the significant increase in SRBs in 1999. We then compare out-of-sample forecasting of different models for the full sample of the Weapons Control group. The same analysis was carried out for the other skill groups but is not presented here. The main result is that the Information-Theoretic GME non-ACOL model is the superior model under all criteria investigated.

Out-of-sample Forecasting of the SRB Experiment

Based on real data, in this example we study the validity of the SRB experiments for different models. Investigating the data we learn that between 1998 and 1999 there is a significant increase in SRB for both the Sensor Operations and Weapons Control groups. Specifically, from an SRB range of 0–4.5 and mean of 0.35 in 1998, the SRB range increased to 6.5 with a mean of 0.67 in 1999 for the Sensor Operations group. Similarly, for the Weapons Control, SRB increased from a range of 0–5.5 in 1998 to 0–7.0 in 1999. In both cases there is a significant increase in the number of reenlisted personnel in 1999. We used this observation and data to perform the following experiment.

1. Estimate the pre-1999 data (2 cases: 1998 only–Case A; 1995–1998–Case B).
2. For each estimation model, perform SRB experiments with the pre-1999 data.
3. Compare the impact of the SRB increases with the observed values of 1999.

Table 11 summarizes the main results. For each model, we provide the estimated Percentage Point increase as a result of an increase in SRB. Following the experimental design discussed earlier, in Table 11 we present the range of estimated reenlisted personnel for the two groups. Based on the real increase in SRB, for the Sensor Operations group the SRB range is 1–2 while for the Weapons Control group the range is 1–1.5. For each model we present analysis done based on the full data (i.e., all observed individuals in that time period), and analysis based on only the personnel entitled to SRB in that period. For example the ACOL10-Full model presents the range (from 1–2) of percentage point increase in reenlistment as a result of increasing SRB by 1 to 2 points for the Sensor Operations group. The ACOL10-Ent model reflects similar analysis but based on the entitled sub-group only. Note that in the "ACOL" literature the "Full" model is the model always used.

Table 11
Range of estimated percentage point change as a result of change in SRB—pre-1999 data

	Sensor Operations		Weapons Control	
	Case A	**Case B**	**Case A**	**Case B**
Full Sample	**16.9**	**5.2**	**23.0**	**18.1**
Entitled Only	**19.3**	**10.0**	**27.4**	**16.5**
ACOL10-Full	0.4–1.8	0.3–0.6	0.3–0.5	0.3–0.5
ACOL10-Ent	4.7–24.6	8.9–17.8	6.8–10.5	5.8—8.9
ACOL20-Full	0.8–5.4	1.0–2.0	1.1–1.65	1.1—1.7
ACOL20-Ent	10.8–51.8	18.5–37.0	7.5–18.5	9.6–14.7
ACOL40-Full	NA	NA	3.6–5.4	3.6–5.4
ACOL40-Ent	NA	NA	15.0–26.7	11.6–20.4
GME-Full	8.6–15	12.6–22.5	8.4–12.6	12.9–18.5
GME-Ent	13.7–24.0	18.7–33.6	13.7–20.5	20.5–30.1

Notes: Bold numbers (rows 3–4) reflect the correct observed changes
1. Case A. Using only the 1998 sample.
2. Case B. Using all data prior to 1999 (1995–1998).
3.All GME results are based on the higher discounted factor case.

The most important results here are:

1. The GME non-ACOL yielded better estimates based on the experiment (estimates that are closer to the observed data in 1999—rows 3–5 of Table 11). For example, consider the Sensor Operation group. Based on the full data (Case A) the increase in reenlistment in 1999 was 16.9 percent and 19.3 percent for the entitled subgroup. With the 2 points increase in SRB, the GME predicted an increase of 15 percent for the full model and 24 percent for the entitled subgroup.
2. The ACOL model for the entitled personnel provides much higher values than the traditional ACOL experiment done on the full model.
3. The ACOL model is very sensitive to the discount factor and whether one analyzes the full data or just the entitled personnel.

Tables 12 through 15 provide the detailed analyses of both groups. The basic results presented in those tables are summarized in Table 11 above.

Table 12
Sensor operations SRB experiment of forecasting from 1995–1998 to 1999. Percentage point increase in reenlistment

	Base	SRB + 0.5	SRB + 1	SRB + 1.5	SRB + 2	Base Prob (Reenlist)	Mean SRB	Mean $ SRB	Range SRB	Observations
GME	1	9.8	18.7	26.6	33.6	0.3466	0.51	$1,753	0, 4.5	7,282
ACOL (10%) ML-Logit Basic			0.3			0.3266	.34	$1,176	0, 4.5	10,852
ACOL (20%) ML-Logit Basic			1.0			0.3266	0.34	$1,176	0, 4.5	10,852
ACOL (20%) ML-Logit Extended			0.7			0.3266	0.34	$1,176	0, 4.5	10,852
ACOL (10%) ML-Multi-Logit			0.5				0.34	$1,176	0, 4.5	10,852
ACOL (20%) ML-Multi-Logit			1.7				0.34	$1,176	0, 4.5	10,852
ACOL (10%) ML-Logit Extended Entitled			8.9				0.51	$1,753	0, 4.5	7,282
ACOL (20%) ML-Logit Extended Entitled			18.5				0.51	$1,753	0, 4.5	7,282
1995-98 Full Data						0.3266	0.34	$1,176	0, 4.5	10,852
1998 Full Data						0.2940	0.35	$1,166	0, 4.5	2,980
1999 Full Data						0.3437	0.67	$2,257	0, 6.5	2,645
1995-98 Entitled						0.3467	0.51	$1,753	0, 4.5	7,282
1998 Entitled						0.3196	0.55	$1,863	0, 4.5	1,865
1999 Entitled						0.3814	1.14	$3,827	0, 6.5	1,560

Changes from 1995-8 period to 1999 are: 5.2 percent reenlist
Changes from 1998 period to 1999 are: 16.9 percent reenlist

Table 13
Sensor Operations SRB experiment of forecasting from 1998 to 1999. percentage point increase in reenlistment

	Base	SRB + 0.5	SRB + 1	SRB + 1.5	SRB + 2	Base Prob (Reenlist)
GME	1	7.4	13.7	19.1	24.0	0.3194
ACOL (10%) ML-Logit Basic			0.4			
ACOL (20%) ML-Logit Basic			1.3			
ACOL (20%) ML-Logit Extended			0.8			
ACOL (10%) ML-Multi-Logit			0.9			
ACOL (20%) ML-Multi-Logit			2.7			
ACOL (10%) ML-Logit Extended Entitled			12.3			
ACOL (20%) ML-Logit Extended Entitled			25.9			
ACOL (10%) ML-Probit Extended Entitled			11.1			
ACOL (20%) ML-Probit Extended Entitled			21.3			
ACOL)10%) ML-Logit Basic Entitled			4.7			
ACOL (20%) ML-Logit Basic Entitled			11.5			
ACOL (20%) ML-Multi-Logit Basic Extended			10.8			

Table 14

Weapons Control SRB Experiment of forecasting from 1995–1998 to 1999. Percentage point increase in reenlistment

	Base	SRB + 0.5	SRB + 1	SRB + 1.5	SRB + 2	Base Prob (Reenlist)	Mean SRB	Mean $ SRB	Range SRB	Observations
GME	1	10.4	20.5	30.1	39.2	0.3409		$1,239		22,130
ACOL (10%) Logit Basic			0.3							35,220
ACOL (20%) Logit Basic			1.1							35,220
ACOL (40%) Logit Basic			3.6							35,220
ACOL (10%) Logit Entitled			5.9							22,130
ACOL (20%) Logit Entitled			9.8							22,130
ACOL (40%) Logit Entitled			13.6							22,130
ACOL (10%) ML-Logit Extended			5.8							22,130
ACOL (20%) Multi-Logit Entitled			9.6							22,130
ACOL (40%) Multi-Logit Entitled			11.6							22,130
1995-98 Full Data						0.2862	0.22	$ 778	0, 5.5	35,220
1998 Full Data						0.2747	0.28	$ 943	0, 5.5	8,646
1999 Full Data						0.3380	0.43	$1,461	0, 7	8,331
1995-98 Entitled						0.3409	0.35	$1,238	0, 5.5	22,130
1998 Entitled						0.3117	0.45	$1,536	0, 5.5	5,307
1999 Entitled						0.3972	0.74	$2,538	0, 7	4,783

Note: The ACOL basic and extended model yielded almost the same results here.

Table 15
Weapons Control SRB experiment of forecasting from 1998 to 1999. Percentage point increase in reenlistment

	Base	SRB + 0.5	SRB + 1	SRB + 1.5	SRB + 2	Base Prob (Reenlist)	Mean $ SRB	Observations
GME	1	6.9	13.7	20.5	27.1	0.3117	1,536	5,307
ACOL (10%) ML-Logit Basic			0.3					35,220
ACOL (20%) ML-Logit Basic			1.1					
ACOL (40%) ML-Logit Basic			3.6					
ACOL (10%) ML-Logit Basic Entitled			6.8					5,307
ACOL (20%) ML-Logit Basic Entitled			7.5					5,307
ACOL (40%) ML-Logit Basic Entitled			15.0					5,307
ACOL (10%) ML-Probit Extended Entitled			7.0					
ACOL (20%) ML-Probit Extended Entitled			12.3					
ACOL (40%) ML-Logit Extended Entitled			17.8					
ACOL (10%) ML-Logit-Multi Entitled			6.9					
ACOL (20%) ML-Logit-Multi Entitled			12.1					
ACOL (40%) ML-Logit-Multi Entitled			17.6					

Comparison of ACOL ML and non-ACOL GME

The following set of statistics and tables show that for all models and cases tested, the non-ACOL GME model dominates in terms of out-of-sample forecasting as well as for in-sample statistics.

Example—Weapons Control

In this subsection a number of examples are presented. In each case, competing models are used to estimate the same data and the relevant statistics, the prediction tables and out-of-sample forecasting comparisons are reported. Most tables are taken directly from the LIMDEP output. To keep this presentation short, the estimated values, marginal effects, and elasticities are not reported here. In all examples below, we use the Weapons Control data from 1995—2000 was used and forecasted into the next two years, 2001–2002. The forecasted period has 11,954 observations.

Case A—Full sample: GME

Information Statistics for Discrete Choice Model.

	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-47981.21293	-51780.42135	-52531.24519
LR Statistic vs. MC	7598.41684	.00000	.00000
Degrees of Freedom	40.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	8513.17426	12381.75890	13132.81130
Normalized Entropy	.64824	.94281	1.00000
Entropy Ratio Stat.	9239.27409	1502.10480	.00000
Bayes Info Criterion	96337.97870	103936.39554	105438.04324
BIC - BIC(no model)	9100.06454	1501.64770	.00000
Pseudo R-squared	.35176	.00000	.00000
Pct. Correct Prec.	63.97858	42.32056	33.33333

Means:	y=0	y=1	y=2	y=3	yu=4	y=5,	y=6	y>=7
Outcome	.4012	.1756	.4232	.0000	.0000	.0000	.0000	.0000
Pred.Pr	.3512	.1589	.4899	.0000	.0000	.0000	.0000	.0000

Prediction table

	Predicted			
Actual	0	1	2	Total
0	3110	207	1479	4796
1	568	232	1299	2099
2	625	128	4306	5059
Total	4303	567	7084	11954

Case B—Full sample GME with 5 points in the errors' support

Information Statistics for Discrete Choice Model.

	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-66296.34477	-70099.59273	-70850.47371
LR Statistic vs. MC	7606.49592	.00000	.00000
Degrees of Freedom	40.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	8511.85054	12381.75890	13132.81130
Normalized Entropy	.64814	.94281	1.00000
Entropy Ratio Stat.	9241.92152	1502.10480	.00000
Bayes Info Criterion	132968.24238	140574.73831	142076.50028
BIC - BIC(no model)	9108.25790	1501.76197	.00000
Pseudo R-squared	.35186	.00000	.00000
Pct. Correct Prec.	63.97858	42.32056	33.33333

Means:	y=0	y=1	y=2	y=3	yu=4	y=5,	y=6	y>=7
Outcome	.4012	.1756	.4232	.0000	.0000	.0000	.0000	.0000
Pred.Pr	.3512	.1589	.4899	.0000	.0000	.0000	.0000	.0000

Prediction table

	Predicted			
Actual	0	1	2	Total
0	3110	207	1479	4796
1	568	232	1299	2099
2	625	128	4306	5059
Total	4303	567	7084	11954

Case C—Binary ML-Logit ACOL 20 % discount extended model

Information Statistics for Discrete Choice Model.

	M=Model	MC=Constants Only	M0=No Model
Criterion F (log L)	-6959.06798	-8144.32729	-8285.88140
LR Statistic vs. MC	2370.51861	.00000	.00000
Degrees of Freedom	15.00000	.00000	.00000
Prob. Value for LR	.00000	.00000	.00000
Entropy for probs.	6918.33020	8144.32729	8285.88140
Normalized Entropy	.83495	.98292	1.00000
Entropy Ratio Stat.	2735.10240	283.10822	.00000
Bayes Info Criterion	14058.96829	16429.48689	16712.59511
BIC - BIC(no model)	2653.62682	283.10822	.00000
Pseudo R-squared	.14553	.00000	.00000
Pct. Correct Prec.	67.91032	.00000	50.00000

Means:	y=0	y=1	y=2	y=3	yu=4	y=5,	y=6	y>=7
Outcome	.5768	.4232	.0000	.0000	.0000	.0000	.0000	.0000
Pred.Pr	.5601	.4399	.0000	.0000	.0000	.0000	.0000	.0000

Note: the basic model does not perform well, and the computer program did not converge, so it is not reported here.

Prediction table

	Predicted		
Actual	0	1	Total
0	4894	2001	6895
1	1835	3224	5059
Total	6729	5225	11954

Case D—Binary ML-Logit ACOL with 10 % discount (ML ACOL–extended)

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model   |
| Criterion F (log L)    -7024.00448       -8144.32729   -8285.88140   |
| LR Statistic vs. MC     2240.64562            .00000        .00000   |
| Degrees of Freedom        15.00000            .00000        .00000   |
| Prob. Value for LR          .00000            .00000        .00000   |
| Entropy for probs.      6957.84819        8144.32729    8285.88140   |
| Normalized Entropy          .83972            .98292       1.00000   |
| Entropy Ratio Stat.     2656.06641         283.10822        .00000   |
| Bayes Info Criterion   14188.84128       16429.48689   16712.59511   |
| BIC - BIC(no model)     2523.75383         283.10822        .00000   |
| Pseudo R-squared            .13756            .00000        .00000   |
| Pct. Correct Prec.        67.03196            .00000      50.00000   |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7  |
| Outcome      .5768  .4232  .0000  .0000  .0000  .0000  .0000  .0000  |
| Pred.Pr      .5613  .4387  .0000  .0000  .0000  .0000  .0000  .0000  |
+----------------------------------------------------------------------+
+-----------------------------------------+
| Fit Measures for Binomial Choice Model  |
| Logit    model for variable ENLIST01    |
+-----------------------------------------+
| Proportions P0= .576794    P1= .423206  |
| N =    11954 N0=    6895   N1=    5059  |
| LogL = -7024.00448 LogL0 = -8144.3273   |
| Estrella = 1-(L/L0)^(-2L0/n) = .18262   |
+-----------------------------------------+
|     Efron |  McFadden  |  Ben./Lerman   |
|    .16989 |    .13756  |       .59780   |
|    Cramer | Veall/Zim. |     Rsqrd_ML   |
|    .18103 |    .27370  |       .17092   |
+-----------------------------------------+
```

Prediction table

```
                    Predicted
------   ----------  +  -----
Actual        0     1 |  Total
------   ----------  +  -----
  0      4851 2044  |   6895
  1      1897 3162  |   5059
------   ----------  +  -----
Total    6748 5206  |  11954
```

Case E—Binary ML-Logit ACOL with 40 % discount (ML ACOL extended)

```
+----------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.                    |
|                            M=Model MC=Constants Only   M0=No Model   |
| Criterion F (log L)    -6808.94442      -8144.32729   -8285.88140   |
| LR Statistic vs. MC     2670.76574           .00000        .00000   |
| Degrees of Freedom        15.00000           .00000        .00000   |
| Prob. Value for LR          .00000           .00000        .00000   |
| Entropy for probs.      6813.07760       8144.32729    8285.88140   |
| Normalized Entropy          .82225           .98292       1.00000   |
| Entropy Ratio Stat.     2945.60759        283.10822        .00000   |
| Bayes Info Criterion   13758.72116      16429.48689   16712.59511   |
| BIC - BIC(no model)     2953.87395        283.10822        .00000   |
| Pseudo R-squared            .16396           .00000        .00000   |
| Pct. Correct Prec.        69.51648           .00000      50.00000   |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7 |
| Outcome      .5768  .4232  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .5556  .4444  .0000  .0000  .0000  .0000  .0000  .0000 |
+----------------------------------------------------------------------+
```

```
+-----------------------------------------+
| Fit Measures for Binomial Choice Model  |
| Logit    model for variable ENLIST01    |
+-----------------------------------------+
| Proportions P0= .576794    P1= .423206  |
| N =    11954 N0=    6895   N1=    5059  |
| LogL = -6808.94442 LogL0 = -8144.3273   |
| Estrella = 1-(L/L0)^(-2L0/n)  = .21653  |
+-----------------------------------------+
|     Efron |  McFadden  |  Ben./Lerman   |
|    .20667 |    .16396  |       .61200   |
|    Cramer | Veall/Zim. |     Rsqrd_ML   |
|    .21191 |    .31664  |       .20022   |
+-----------------------------------------+
| Information  Akaike I.C. Schwarz I.C.   |
| Criteria         1.14187   13768.10998  |
+-----------------------------------------+
```

Prediction table

```
                Predicted
------   ----------  +  -----
Actual        0    1 |  Total
------   ----------  +  -----
  0        4918 1977 |   6895
  1        1667 3392 |   5059
------   ----------  +  -----
Total      6585 5369 |  11954
```

Case F—Binary ML-Logit ACOL with binary ML Probit ACOL with 40 % discount factor

```
| Fit Measures for Binomial Choice Model |
| Probit   model for variable ENLIST01   |
+----------------------------------------+
| Proportions P0= .576794   P1= .423206  |
| N =    11954 N0=     6895   N1=     5059 |
| LogL = -6823.04000 LogL0 = -8144.3273  |
| Estrella = 1-(L/L0)^(-2L0/n) = .21432  |
+----------------------------------------+
|     Efron |  McFadden  |   Ben./Lerman |
|    .20409 |     .16223 |        .60921 |
|    Cramer | Veall/Zim. |      Rsqrd_ML |
|    .20534 |     .31390 |        .19833 |
+----------------------------------------+
| Information  Akaike I.C. Schwarz I.C.  |
| Criteria         1.14423  13796.30114  |
+----------------------------------------+
```

Prediction table

```
------  ----------  +  -----
Actual      0    1  |  Total
------  ----------  +  -----
  0      4953 1942  |   6895
  1      1731 3328  |   5059
------  ----------  +  -----
Total    6684 5270  |  11954
```

Case G—ML Logit 3 category extended ACOL with 40 % discount

```
| Criterion F (log L)    -9758.05430       -12381.75890  -13132.81130 |
| LR Statistic vs. MC     5247.40921             .00000        .00000 |
| Degrees of Freedom        30.00000             .00000        .00000 |
| Prob. Value for LR          .00000             .00000        .00000 |
| Entropy for probs.      9947.62829        12381.75890   13132.81130 |
| Normalized Entropy          .75746             .94281       1.00000 |
| Entropy Ratio Stat.     6370.36601         1502.10480        .00000 |
| Bayes Info Criterion   19797.77323        25045.18244   26547.28723 |
| BIC - BIC(no model)     6749.51401         1502.10480        .00000 |
| Pseudo R-squared            .21190             .00000        .00000 |
| Pct. Correct Prec.        63.35954             .00000      33.33333 |
| Means:        y=0    y=1    y=2    y=3    yu=4   y=5,   y=6    y>=7  |
| Outcome      .4012  .1756  .4232  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr      .3827  .1697  .4476  .0000  .0000  .0000  .0000  .0000 |
```

Prediction table

```
              Predicted
------  ---------------  +  -----
Actual      0    1    2  |  Total
------  ---------------  +  -----
  0      3099  218 1479  |   4796
  1       595  434 1070  |   2099
  2       837  181 4041  |   5059
------  ---------------  +  -----
Total    4531  833 6590  |  11954
```

Case H—GME non-ACOL binary model

```
+------------------------------------------------------------------+
| Information Statistics for Discrete Choice Model.               |
| Criterion F (log L)   -31955.26436      -34409.98184  -34551.50399 |
| LR Statistic vs. MC     4909.43497            .00000        .00000 |
| Degrees of Freedom        20.00000            .00000        .00000 |
| Prob. Value for LR          .00000            .00000        .00000 |
| Entropy for probs.      5706.68364        8144.32729    8285.88140 |
| Normalized Entropy          .68872            .98292       1.00000 |
| Entropy Ratio Stat.     5158.39551         283.10822        .00000 |
| Bayes Info Criterion   64098.30514       69007.74011   69290.78441 |
| BIC - BIC(no model)     5192.47927         283.04430        .00000 |
| Pseudo R-squared            .31128            .00000        .00000 |
| Pct. Correct Prec.        72.77899          57.67944      50.00000 |
| Means:         y=0    y=1    y=2    y=3    yu=4   y=5,    y=6   y>=7 |
| Outcome       .5768  .4232  .0000  .0000  .0000  .0000  .0000  .0000 |
| Pred.Pr       .5092  .4908  .0000  .0000  .0000  .0000  .0000  .0000 |
+------------------------------------------------------------------+
```

Prediction table

```
               Predicted
------  ----------  +  -----
Actual      0    1  |  Total
------  ----------  +  -----
  0      4958 1937  |   6895
  1      1317 3742  |   5059
------  ----------  +  -----
Total    6275 5679  |  11954
```

In all of the above cases, the non-ACOL GME has good performance relative to the ACOL ML models. The GME non-ACOL has better in-sample performance as well as superior out-of-sample performance (presented in the Prediction Tables above). More comparisons revealed the same outcome but are not presented here to save space.

Binary vs. Multinomial Choice Retention Models

In this section we try, via an example, to answer the question whether an increase in SRBs serves more to change the length of reenlistment (from short-term to long-term) rather than affecting the total number of people who reenlist.

Unfortunately the answer is profession/group dependent. Below are two examples (Weapons Control and Sensor Operation). Both are on the "high" end and both have a large number of SRB recipients so the estimates are quite accurate. Regardless of the way we analyze (either by entitled subgroup—as discussed in draft report, or by the full sample—the "biased" estimates), the signs and magnitudes are similar.

In the Sensor Operations group, SRB increase results in a small decline (1–2.1%) of extensions and a significant increase in reenlisted (about 7.6%). The decrease in "Leave" is approximately 5.7 percent.

Table 16
Results of SRB Increase by a unit on all three choices (leave, extend, reenlist) Sensor Operation Group

Sensor Op — Entitled group analysis (12,923 obs)					
	Original Estimate	**SRB + 1 (inf)**	**SRB + 1 (0 Discount)**	**% change**	***Normalized/ adjusted % change***
Leave	.4198	.3814	.3551	-9.1	*-5.7*
Extend	.2012	.1943	.1788	-3.4	*-2.1*
Reenlist	.3790	.4244	.4661	12.0	*7.6*
Sensor Op — Full sample analysis (20,512 obs)					
	Original Estimate	**SRB + 1 (inf)**	**SRB + 1 (0 Discount)**	**% change**	***Normalized/ adjusted % change***
Leave	.4017	.3731	.3548	-7.1	N/A
Extend	.2540	.2515	.2417	-1.0	N/A
Reenlist	.3443	.3754	.4035	9.0	N/A

In the Weapons Control group, on the other hand, we observed an increase in extension together with a sharper increase in reenlistment as a result of the SRB increase experiment.

Table 17
Results of SRB increase by a unit on all three choices (leave, extend, reenlist) Weapons Control Group

Weapons Control — Entitled (40,381 obs)					
	Original Estimate	**SRB + 1 (inf)**	**SRB + 1 (0 Discount)**	**% change**	***Normalized/ adjusted % change***
Leave	.4337	.3376	.2627	-22.2	*-13.5*
Extend	.1547	.1681	.1700	8.7	*5.3*
Reenlist	.4116	.4944	.5673	20.1	*12.2*
Weapons Control — Full Sample (66,509 obs)					
	Original Estimate	**SRB + 1 (inf)**	**SRB + 1 (0 Discount)**	**% change**	***Normalized/ adjusted % change***
Leave	.4615	.4008	.3554	-13.2	N/A
Extend	.2032	.2123	.2135	4.5	N/A
Reenlist	.3353	.3869	.4311	15.4	N/A

Note that in all cases, by construction of the experiment (in all types of models), the total change of all three choices must be exactly zero (i.e., the probabilities sum to 1).

The above results demonstrate that the SRB impacts are profession specific. In some cases SRB increase causes individuals to increase length of extension or to switch from Extend to Reenlist. In other cases, both (Reenlist and Extend) may increase while "Leave" decreases.

To present the results more visually, another view is given with the following figures representing the Sensor Operation case.

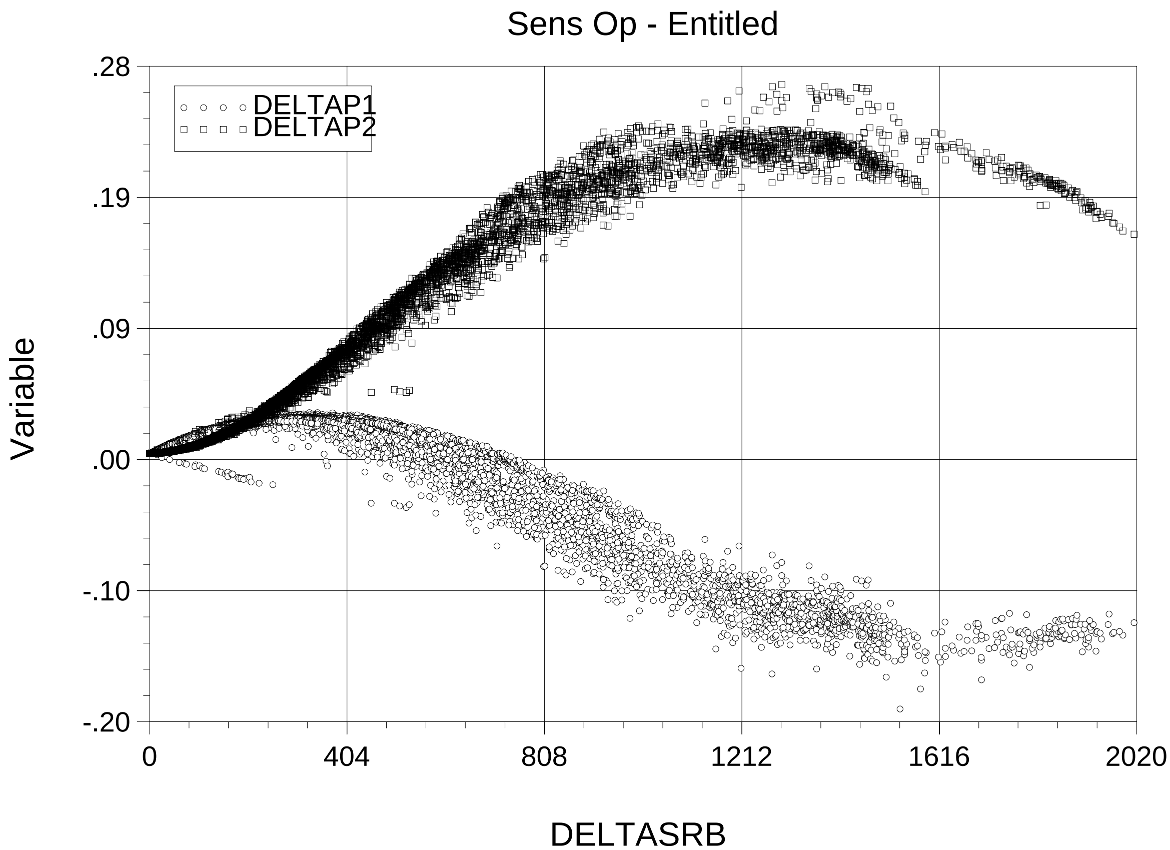

Figure 34. The change in extensions (Deltap1) and the change in reenlistment (Deltap2) vs. the change in dollar value of SRB (Deltasrb).

Note that reenlistment change is fast and positive while extension increases for lower values and then becomes negative as individuals switch to the reenlist category. (Note: Deltap2 = original estimated probability (reenlist)—New Probability (reenlist) as SRB increases by 1; Deltap1 and Deltasrb are similar).

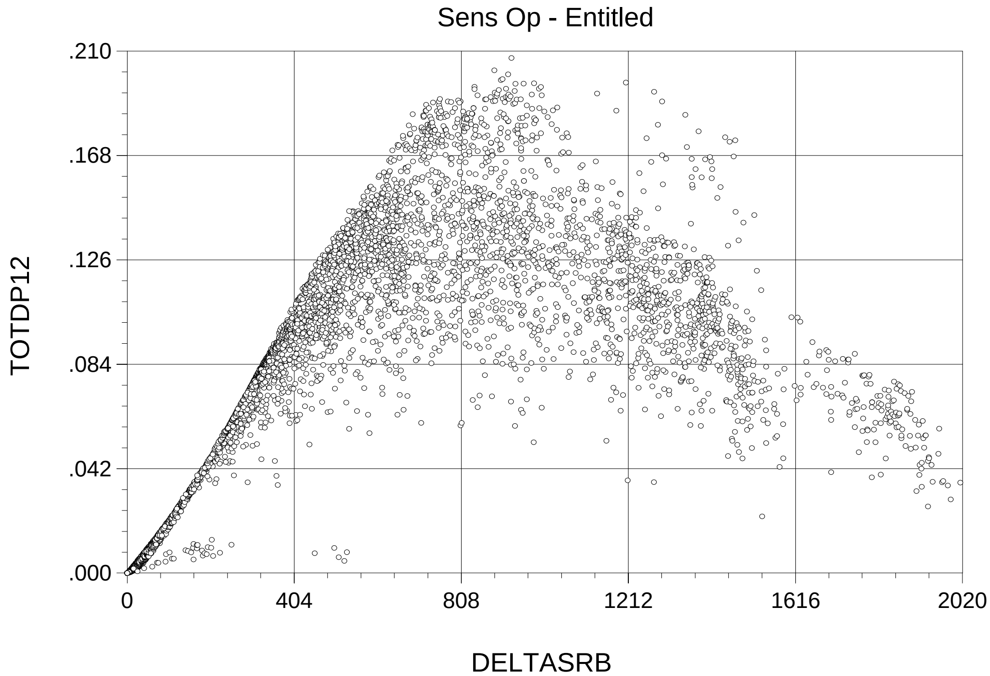

Figure 35. The TOTAL change in extension and reenlistment (TotDP12=Deltap1+Deltap2) vs. the change in dollar value of SRB (Deltasrb).

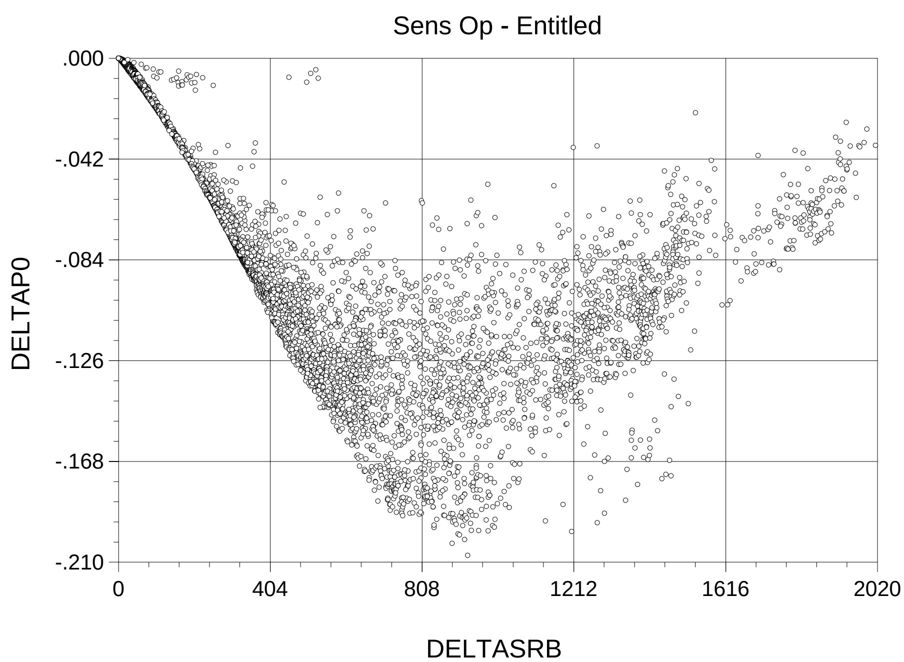

Figure 36. The change in "leave" (Deltap0) vs. the change in dollar value of SRB (Deltasrb) ("mirror image" of Figure 35).

Unemployment Effects

In general, over the sample period (1995–2002) enlisted personnel became less sensitive to the unemployment rate. This result is consistent throughout subsets of the data, across models (ACOL, non-ACOL, ML, GME, etc.), and across the different unemployment measures (general, by education, and others). Table 18 shows these results for the Weapons Control group.

There are probably a number of explanations for this result and more is needed from those who are familiar with the changes in rules and policies such as downsizing certain professions. But one observation is notable here: the mean quality (AFQT) of enlisted personnel (only for Weapons Control) increased during that period, which may explain part of the reduction in sensitivity toward unemployment (higher quality personnel are, on average, less sensitive to unemployment). Other explanations, observed in the other data sets include a dramatic increase in SRB (from approximately 0.3 in mid-90s on average for the Sensor Operation group) to approximately 0.9 in 2001–2. This reflects a substantial average increase of SRB payments.

Table 18
Weapons Control—unemployment analysis

Evaluated at			1995-1996	1997-1999	2000-2002
Mean Charac.	Unemp.	GME - 3 categories	-2.17*, -.61,3.27*	-	-.43*, -.12,.14*
	Unemp Education	GME - 3 categories	-.54*, 1.42*, -.24	-.19,.63*, -.33*	-.41*, -.08,.12*
	Unemp.	Binary GME-1	3.2*	-	.29*
	Unemp.	Binary GME-2	1.9*	-	.07*
	Unemp.	Binary ML ACOL-20	3.53*	-	0.41*
	Unemp.	Binary ML ACOL-40	3.55*	-	0.40*
Mean over individuals	Unemp.	GME - 3 categories	-,-.31,3.57*	-	-.3*, .01,.28*
	Unemp Education	GME - 3 categories	-.45*, 1.51*, -.15	-.14,.69*, -.28*	-.28*, .05,.25*
Mean AFQT			72.4	74.7	76

Notes: * significant
Binary GME-1: 0 - leave and extend; 1 - reenlist
Binary GME-2: 0 - leave; 1 - reenlist and extend

To summarize, the individuals may be very sensitive to the unemployment rate (or the lag unemployment), but the macro-economic and political conditions as well as the wage/bonus increases/changes over time, make it hard to prove. Below are the main observations.

1. First, an analysis of the whole period (1995–2002) by groups reveals that except for the Administration group, all unemployment elasticities (with respect to Reenlistment) are positive.
2. For all groups the sensitivity to unemployment declines over time (or becomes statistically insignificant).

Both general unemployment or unemployment by education yield similar results.

Conclusions and Thoughts for Final Research

The main objectives of research were to investigate the sensitivity of enlisted personnel to SRB and other pay components, as well as to investigate the sensitivity of the personnel to the basic economic conditions. Using data from 1995 through 2002, these effects were studied for four basic skill groups: Weapons Control, Sensor Operations, General Seamanship, and Administration. To achieve the above objectives, we needed to start with a thorough model comparison. We compared and contrasted different scenarios of the Maximum Likelihood (ML) ACOL models with the Information Theoretic Non-ACOL GME method. For the ACOL model we suggest a slightly different way of performing the SRB experiment. For the Non-ACOL model we developed a new method of performing the SRB experiment. In that new approach, we also used the estimated reenlistment probability for each individual.

The main results of that research are:

1. The sensitivity of personnel to SRB payments is skill specific and in all cases the enlisted personnel became less sensitive to the SRB payment over the period analyzed.
2. In all cases, enlisted personnel became less sensitive to unemployment levels and to other macroeconomic indicators over time.
3. In cases (skill groups) where we don't observe many individuals that received SRB, the SRB experiments should be done differently than in those cases where a significant portion of the enlisted personnel received SRBs. We provide such an analysis for the General Seamanship skill group.
4. The Non-ACOL GME method yielded superior estimates and forecasts for all cases.
5. The ML-ACOL models are very sensitive to the discount factor used and to other specifications.

In future work it will be interesting to study the rest of the skill groups, to develop the exact functional form (per skill group) of the relationship between pay and reenlistment probability (see General Seamanship analysis), to perform a real experiment studying the SRB impact on enlisted personnel, and to further develop the current model based on the forecasting results shown here.

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