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Variability of valuation of non-monetary incentives motivating and implementing the Combinatorial Retention Auction Mechanism

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THESIS

VARIABILITY OF VALUATION OF NON-MONETARY INCENTIVES: MOTIVATING AND IMPLEMENTING THE COMBINATORIAL RETENTION AUCTION MECHANISM

by

Jason Blake Ellis

March 2009

Thesis Co-Advisors: William Gates
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13. ABSTRACT (maximum 200 words)

This thesis explores the concept of preference variability relative to non-monetary and monetary incentives in the Combinatorial Retention Auction Mechanism (CRAM). CRAM offers a mix of monetary and non-monetary incentives to encourage retention behavior. Recent research demonstrated the utility of non-monetary incentives as part of a military retention program. While CRAM was shown to cost effectively motivate retention, variability in valuation of non-monetary incentives as part of CRAM introduces complexity in eliciting preferences to implement the model. Making certain complexity decreasing assumptions regarding the personal valuation of incentives potentially affects the model cost and retention outcomes. These assumptions could potentially increase costs and retain the "wrong" sailors.

This thesis examines an operational version of the CRAM, which assumes additive personal preferences across combinations of nonmonetary incentives to decrease complexity of the model. The outcomes of this "simplified" model are compared to the "more complex" previous research findings. The simplified CRAM model continues to produce cost saving, with no significant changes to the mix of personnel retained. Overall, results of the CRAM assuming additive personal preferences across combinations of nonmonetary incentives are not significantly different than the more complex model.

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VARIABILITY OF VALUATION OF NON-MONETARY INCENTIVES: MOTIVATING AND IMPLEMENTING THE COMBINATORIAL RETENTION AUCTION MECHANISM

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I. INTRODUCTION

A. PURPOSE AND OBJECTIVES

This research expands an ongoing investigation of how sailors value non-monetary incentives as part of a retention package, and how variability in the value sailors place on individual and combinations of incentives could affect cost and retention outcomes in a Combinatorial Retention Auction Mechanism. It examines the magnitude of variation present when CRAM models different variables, if adjustments are required, and what is the best method to accomplish the adjustments.

The ability of the United States military to carry out a multitude of assigned missions depends upon many factors. While technology, mobility, and a strong infrastructure serve to support military operations worldwide, arguably the most significant factor affecting success is the individual soldier, airman, sailor or marine. While the specific service requirements related to personnel change over time, the underlying requirement for a highly motivated, fully trained, and well equipped force to meet U. S. policy and strategy objectives may not. Personnel policies that enable the military to recruit, train, and retain service members with the required skills to meet the military's many missions will always be at the forefront of various U.S. military personnel management systems.

Given the current worldwide political situation and the United States involvement in wide spread campaigns around the globe, the need for experienced personnel that possess the skills required by the military has never been greater. Undoubtedly, today's military has a focus toward retention and needs to predict the incentives necessary to accomplish these crucial missions.

The Department of Defense is a significant sponsor of the current body of research that is applicable to bonus-taking behavior by service members, as well as

alternatives to traditional bonus monetary incentives that might elicit positive retention behavior among service members. This research focuses on cost effective implementation measures.

Recent research has evaluated whether alternatives to monetary-only incentives might provide a viable and cost effective alternative to improve retention efforts in the Navy. Research conducted by LT Brooke Zimmerman found that among monetary-only, Universal incentives (a set of benefits available to all personnel and that does not change), and the Combinatorial Retention Auction Method (CRAM) in which sailors choose the incentives they would like to have in combination with a cash bonus, that CRAM offers the opportunity for the Navy to enjoy required retention rates at overall lower costs, while allowing sailors to individualize their compensation packages and receive the benefits that are of greatest value to them[1]. The results are based upon assumptions given in her research, and should only be generalized to the specific population she evaluated, but are intriguing.

While she did not specifically address the concept of individual choice and empowerment among sailors, certainly it could be expected that freedom to choose retention incentives improves not only retention, but also satisfaction among those retained. The results of this research have compelled further investigation of whether there are opportunities to design and implement retention plans that can efficiently and effectively retain the required sailors to meet the Navy's goals, using CRAM.

There are many reasons to consider alternatives to the traditional selective reenlistment bonus. Currently though, the increasing cost of administering the program could be considered a driving factor. The United States General Accounting Office reported in 1997 that the Selective Reenlistment Bonus burden for the entire Department of Defense was $235 million. During this same period, the individual service member

[1] Brooke Zimmerman, "Integrating Monetary and Non-monetary Reenlistment Incentives Utilizing the Combinatorial Retention Auction Mechanism (CRAM)," (Master's Thesis, Naval Postgraduate School, 2008).

could receive a bonus of up to $60,000, although this offering would be rare.[2] In 2007, the Navy alone eclipsed the $235 million mark set DoD-wide just 10 years earlier, spending over $359 million.[3] Obviously the Selective Reenlistment Bonus (SRB) System is becoming increasingly costly to execute. The increase in SRB spending should lead us to question the potential diminishing returns for the SRB dollar spent.

To address this concern there is a need to consider new methods and structures for retention incentives. Non-monetary incentives could potentially become increasingly important in this process. As shown by Zimmerman, preliminary results addressing non-monetary incentives are promising and show potential retention improvement and cost savings for the Navy. While her research shows promise for the opportunity to utilize non-monetary incentives such as choice of home port assignment or the opportunity to earn specialty certification in the sailor's field of specialty[4], there are complicating factors that must be addressed to achieve success in instituting such a program.

Complicating factors associated with non-monetary incentive implementation occur on the side of individual sailors, and must be fully explored. Specifically, how sailors value individual non-monetary incentives and combinations of non-monetary incentives is not fully understood. Additionally, particular combinations of incentives might be more or less cost effective for the Navy to administer, or valued more or less by the sailor, and therefore offer greater potential retention benefits or cost savings for the Navy. Finally, the variability that is present in the valuation of incentives could potentially affect the outcomes of a program designed to offer non-monetary incentives. These complicating factors are the basis for this research.

This research explores an extensive background of work associated with retention behaviors and the current policies in place to encourage retention. A review of current

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[2] United States General Accounting Office, Military Personnel: Management and Oversight of Selective Reenlistment Bonus Program Needs Improvement (Washington, D.C.: Government Printing Office, 2002), 5. http://www.gao.gov/new.items/d03149.pdf (accessed: 22 January 2009).

[3] United States Department of the Navy, Department of the Navy Fiscal Year (FY) 2009 Budget Estimates Submission, Justification of Estimates, February 2008, Military Personnel, Navy (Washington, D.C.: Government Printing Office, 2008), 85. http://www.finance.hq.navy.mil/FMB/09PRES/MPN_Book.pdf (accessed 22 January 2009).

[4] Zimmerman, "Integrating Monetary and Non-monetary Reenlistment Incentives."

research associated with non-monetary retention incentives and the complicating factors on the "sailor-side" of this topic are addressed as well. Overall, this thesis addresses the issues that most significantly affect the successful implementation of a Combinatorial Retention Auction Incentive Program.

B. ORGANIZATION OF THIS STUDY

This thesis is a continuation of a larger ongoing investigation being conducted by Dr. William Gates and Dr. Peter Coughlan of the Naval Postgraduate School, Monterey, California. This line of research has focused on the potential opportunities for the United States Navy to enjoy improved retention of service members at lower costs. To accomplish this they have investigated various models of how monetary bonuses are offered. These include a tremendous body of work devoted to auction-based compensation. As a method of fully exploring bonus activity, non-monetary incentives have also been addressed, and their research continues here.

While numerous options have been explored, including the use of auction-style mechanisms to administer bonuses, the way in which service members value individual and packages of non-monetary incentives is also a significant aspect of retention incentive research. Implementation of any non-monetary incentive program must address individual preferences, and is a significant component of this thesis.

A thorough literature review and a review of current research devoted to this topic has revealed several student theses related to the design and implementation of auction mechanisms, as well as whether alternative mechanisms offer a cost effectiveness from a retention perspective. These are presented in Table 1 below.

Table 1. Significant Related Research

Author	Year	Significant Findings
Bock[5]	2007	The Sequential Self-Selection Auction Mechanism S^3M can produce significant cost savings for the military.
Denmond, Johnson, Lewis, and Zegley[6]	2007	Combinatorial Auctions (monetary and non-monetary incentive combinations) result in cost-savings to the military
Cook[7]	2008	The second price auction format results in decreased economic rent (cost savings), and retains service members that are more willing to stay (which can be translated into "happier force")
Zimmerman[8]	2008	Combinatorial Auctions (monetary and non-monetary incentive combinations) provide the opportunity for service members to gain more *value* from their bonus while decreasing the actual *costs* to the military

In support of the idea that bonus taking behavior of today's sailors are different than in the past, Chapter II is devoted to evaluating the appeal of non-monetary incentives as potentially part of a retention program. Additionally, Chapter II evaluates the results of four Chief of Naval Personnel "Quick Polls" that address the question of "what do sailors want?"

Chapter III focuses on the nature of variability in incentive preferences. There are several factors of variability to address. These include variability across individual incentives, variability across different populations, variability in the valuation of multiple incentives within a population, and finally, differences in valuation of individual incentives versus combinations of incentives.

The Chapter IV discusses auctions as a force-shaping tool. Auction variations, specifically as they apply in the retention context, are also addressed.

[5] Paul B. Bock, "The sequential self-selection auction mechanism for selective reenlistment bonuses: potential cost savings to the U.S. Marine Corps," (Master's Thesis, Naval Postgraduate School, 2007).

[6] Constance M. Denmond, Derek N. Johnson, Chavius G. Lewis, and Christopher R. Zegley, "Combinatorial Auction Theory Applied to the Selection of Surface Warfare Incentives," (MBA Professional Report, Naval Postgraduate School, 2007).

[7] Benjamin M. Cook, "Using a second-price auction to set military retention bonus levels: an application to the Australian Army," (Master's Thesis, Naval Postgraduate School, 2008).

[8] Zimmerman, "Integrating Monetary and Non-monetary Reenlistment Incentives."

Chapter V addresses the Combinatorial Retention Auction Mechanism. In this discussion, the Combinatorial Retention Auction Mechanism is explained, and is compared to the Universal Incentive Package, (two versions) in terms of ability to adjust for variability. Additionally, these are compared on level of flexibility in meeting individual preferences.

Chapter VI of this thesis addresses the preference elicitation problem, and the multiple complexities associated with administering CRAM. Assumptions that affect the model motivated in this research are also addressed. Chapter VII provides supporting conclusions and recommendations.

C. RESEARCH QUESTIONS

The questions of how to structure bonus systems and to whom to offer the bonus are critical in developing a successful bonus system. Understanding the value service members place on non-monetary incentives a non-monetary incentive program could be structured to exploit the values of various incentives as determined by service members. To fully investigate this question, this thesis will investigate the following questions:

1. Primary Research Question

The primary research question to be addressed, given the assumption that the CRAM offers an opportunity to retain the required number of sailors at a lower cost, and potentially greater individual satisfaction:

> How does the variability in valuations of non-monetary incentives (NMIs) impact the proper use of such incentives as a force-shaping tool?

The primary assumption supporting this question is that service members will place varying values on retention incentives based upon their personal situation and tastes. Individual preferences are a significant focus of this research. It is also assumed that individuals are unique and some sailors will place more or less value on various combinations of incentives than others. Taking into account the individual sailors' valuation of incentives, ultimately it may be possible to provide an equivalent *value* of retention incentive to sailors at a lower overall *cost* to the Navy.

2. Secondary Research Questions

Secondary research questions that will be evaluated include:

- What different types of variability in valuations exist?
- How significant is each type of variability?
- What are the implications of each type of variability for the effective provision of NMIs?
- How does the Combinatorial Retention Auction Mechanism (CRAM) accommodate each type of variability?
- Are there simple variations of the CRAM that still accommodate all types of variability?

Addressing these questions will begin to offer personnel planners and policy makers the opportunity to develop retention incentives to better meet the Navy's personnel requirements.

D. SCOPE

To answer these questions, this thesis will focus on determining which individual non-monetary incentives and combinations of non-monetary incentives are most desired by the respondent population. Additionally, these combinations will be analyzed in terms of whether various combinations of non-monetary incentives hold greater or lower value together, than the sum of their individual values. The variability present in these valuations must be evaluated to fully understand the implications related to CRAM implementation. This knowledge will enable personnel planners to offer the right mix of incentives to meet personnel retention goals. While the findings discussed here apply only to the populations represented from the stated data sets, the findings may be expanded to address the tendencies of similar populations, particularly in the U.S. Navy.

E. METHODOLOGY AND THESIS OVERVIEW

As previously stated, the purpose of this research is to investigate how sailors value combinations of non-monetary incentives as part of a retention package, as well as

determine whether the military needs to adjust for variability in incentive valuation when included as part of a Combinatorial Retention Auction Mechanism. Two relatively recent surveys have been administered to service personnel to understand which non-monetary incentives might be most attractive to Navy personnel, and how much value individuals place on these incentives. These surveys asked respondents to identify the cash bonus that would be required to entice them to retain on active duty for a fixed period of time. Once the individual baseline bonus was established the survey then asked respondents to identify how much of the monetary bonus they would give up in lieu of various non-monetary incentives.

This thesis presents an overview of previous applicable research and how their outcomes affect current research. Additionally, the scope of the current SRB policy dilemma, and the study of auctions as they could potentially apply to the SRB problem as discussed.

The magnitude of the preference variability among sailors and the potential CRAM model implications of this variability will be examined. The research approach is based upon data taken directly from the Surface Warfare Officer and Enlisted Retention Studies respectively. These studies are more fully addressed in Chapter II.

Zimmerman used the Crystal Ball simulation program to elicit retention cost and value to sailors based upon sailor specified criteria. In her study, each individual sailor and their preferences were considered in developing a "bid" that was used to determine his / her retention under the model. Her simulations were based upon the results of the Enlisted Retention Study, which provided data to model a reverse, multiple attribute, second-price auction. She was successful in showing the theory and utility of the model she used to meet retention targets with a significant cost savings.

Given the nature of multiple attributes (in this case individual preferences and valuations), it would be very time consuming to consider each individual and combination of preferences for every sailor. As a method of decreasing the complexity of the model, and therefore the necessity of obtaining information from each individual sailor about every possible combination of available incentives, this thesis hypothesizes

that the sailor valuation of all incentive combinations can be modeled as strictly additive over the individual incentive values. To explore this hypothesis, we alter the model to assume that individual preferences are purely additive, and analyze whether the results of the simplified mechanism differ significantly from the results obtained by Zimmerman. It would simplify implementation if similar results can be obtained without requiring the tremendous workload of eliciting every combinatorial preference from each and every sailor.

F. DATA SETS

The data used for this research is derived from the two surveys previously identified. Given the nature of the questions posed in the surveys, it is assumed that the answers returned represent the true valuation individuals place on the respective incentives, and can be considered reliable enough to simulate actual behavior, but not precisely accurate conclusions. These data sets, along with four personnel surveys administered by the Chief of Naval Personnel, will be more fully explored in Chapter III.

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II. THE APPEAL OF NON-MONETARY INCENTIVES

Volumes have been written about the theory and application of retention incentives to today's military. Recent research on which this thesis is based addressed whether there is an opportunity to improve the method by which retention bonuses are administered in the United States Navy.

Non-monetary incentives represent one way in which personnel planners can offer retention incentives at a lower overall cost to the Navy, while also potentially meeting the personal goals of the individual sailor. While civilian organizations have long taken advantage of the flexibility that comes with such programs, the military has only recently begun to take a concentrated look at this area.

A. SCOPE OF THE SELECTIVE REENLISTMENT BONUS DILEMMA

The selective reenlistment bonus is a tool that policy makers use to shape the military services with the right number of people with the right skills necessary to carry out the military's multiple and varied missions. The idea of paying a Selective Reenlistment Bonus is not new. In fact, an SRB was first considered by our founding father, George Washington. As early as 1776, Washington wrote to Congress:

> That if Congress have any reason to believe, that there will be occasion for Troops another year, and consequently of another enlistment, they would save money and have infinitely better troops if they were, even at a bounty of twenty, thirty or more dollars, to engage the men already enlisted.[9]

In his letter, Washington expressed the nature of the retention problem with brevity and clarity. Obviously he understood the benefit of a bonus to retain service members with the skills a military requires. But, knowing the benefit of retention does little to solve the problem of striking a balance between the loss of military members who

[9] John C. Fitzpatrick (ed.), The Writings of George Washington, Vol. 4, Washington, D.C.: U.S. Government Printing Office, 1931, 317.

are less expensive or more easily replaced and retention of those who are either hard to access or costly to replace. The latter is becoming more challenging in today's environment.

While the selective reenlistment bonus is a flexible tool to address retention needs, it is not without problems. The current method of administering SRB's is outlined in the following section, and sheds light on the nature of the problem. Arguably the most troubling aspect of the SRB dilemma is the possibility of decreasing marginal returns. The introductory chapter of this thesis discussed the magnitude of change related to payment of SRBs over the past several years. The selective reenlistment bonus requirement has dramatically outpaced the force structure requirement resulting in significantly higher SRBs required to retain the same number of service personnel.

A natural question that arises from the increasing SRB requirement over time is whether service members are becoming less responsive to SRBs over time. To date, no studies have provided conclusive evidence that service members have become less responsive to SRB offerings. For example, Hansen and Wenger (2005) concluded that while sailors have changed over time, their responsiveness to changes in pay, bonus, etc. have not.[10] This still leaves the question of the increasing SRBs over time. The nature of offering more reenlistment bonus dollars to retain the same number of sailors does lead one to question whether there might be a decrease in responsiveness.

B. BUREAU OF NAVAL PERSONNEL QUICK POLLS (WHAT DO SAILORS WANT?)

The Bureau of Naval Personnel conducts research for the Department of the Navy, including surveys designed to determine sailor's satisfaction with all aspects of Naval service. Generally these surveys are fielded as "Quick Polls" designed to test the "pulse" of the Navy.

Officer and Sailor satisfaction are key indicators of retention propensity and probability, the results of which can provide useful information for personnel planners.

[10] Michael Hansen & Jennie W. Wenger, Is the Pay Responsiveness of Enlisted Personnel Decreasing? *Defence and Peace Economics*. Vol 16 (1); February, 29-43.

Included below are the significant findings of four separate surveys administered since 2003. Each of these lends insight to the attitudes of sailors from various segments of the Naval Service.

1. Selective Reenlistment Bonus Quick Poll[11]

- Fielded February, 2003: 458 respondents in grades E4-E6
- Of those SRB eligible, SRB was ranked highest in regards to affecting reenlistment intention; of those not SRB eligible, geographic location and choice of job assignment ranked highest in regards to affecting reenlistment intention (but only 31% indicated becoming eligible for an SRB would be a factor in this decision)
- 67% of those eligible to reenlist would not reenlist if an SRB were not offered

2. Surface Warfare Officer Quick Poll[12]

- Fielded June, 2004: 4,448 Surface Warfare Officers in grade O1-O4
- 2,128 respondents (47% response rate)
- A number of incentives, including guaranteed education and geographic stability after Department Head tours ranked higher than SWO Continuation Pay (SWOCP) as affecting potential continuation decisions
- Officers in all grades indicated an increased propensity to continue as the level of SWOCP increased, indicating increasing SWOCP would likely result in greater continuation

[11] Navy Personnel Research, Studies, and Technology (2003). Selective Reenlistment Bonus Quick Poll. Millington, TN: C. Newell; K. Whittam; Z. Uriell.

[12] Navy Personnel Research, Studies, and Technology (2004). Surface Warfare Officers (SWO) Continuation Intentions Quick Poll. Millington, TN: C. Newell; K. Whittam; Z. Uriell.

3. Medical Department Officer Quick Poll[13]

- Fielded May, 2005: 10,872 Medical Department Officers
- 3,582 Respondents (33% response rate)
- Across the Medical Department, both choice of job assignment and choice of geographic location for next assignment ranked higher than retention bonus, in terms of increasing the likelihood to remain on active duty

4. 2007 Retention Quick Poll[14]

- Fielded December 2007 to January 2008: 8,000 sailors, random sample
- Obtained a 43% response rate
- Top three incentives to reenlist / continue:
  - Enlisted: Increase base pay; Choice of geographic location; Increase bonus
  - Officer: Increase base pay; Choice of geographic location; Choice of next assignment

It is important to note that in all surveys which asked the question, an increase in Basic Pay was found to be a significant factor in reenlistment/continuation decisions. Basic pay increase consistently ranked among the top five indicators of reenlistment/continuation intention.

The results of this series of quick polls are interesting in terms of effects that can be found related to retention and continuation decisions. At a minimum, these surveys lend support to the assumptions postulated in the series of studies related to non-monetary incentives as a viable alternative to monetary only offerings.

[13] Navy Personnel Research, Studies, and Technology (2005), 2005 Medical Officer Quick Poll. Millington, TN: C. Newell; K. Whittam, Z. Uriell.

[14] Navy Personnel Research, Studies, and Technology (2007), 2007 Retention Quick Poll. Millington, TN: Schultz, R.; C. Newell; K. Whittam, Z. Uriell.

III. VARIABILITY IN NON-MONETARY INCENTIVE VALUATIONS

Before discussing how incentives might be considered as a part of compensation, it is imperative to make a distinction between *costs* and *value* as they apply to the line of research examined in this field. Costs represent the relative expense that the Navy would bear to provide a given incentive to the service member. In terms of this thesis and the research reviewed, cost includes the cost of providing non-monetary incentives, as well as the cost of any additional monetary bonus. As discussed in the methodology section of the above studies, up to this point cost has been measured against a relative valuation determined by the surveyed population. If the Navy is able to reasonably approximate the actual cost to provide various non-monetary incentives, then accuracy in determining the effects of the models will be greatly improved.

Value is a relative term. The value of an item, object, or incentive is assigned by the person who is evaluating the item. The concept of value versus cost is significant in determining incentive offerings, as well as the overall results of savings achieved by the Navy and value gained by the sailor. If an individual service member values an incentive more than it costs the Navy to provide, then both the Navy and individual gain from providing this incentive as part of a retention package. How much of a gain the individual receives is determined by how much the individual values the incentive.

To illustrate the concepts of costs and value, consider the following example:

A sailor in San Diego is entitled to a selective reenlistment bonus of fifty thousand dollars. The sailor might choose to give up $10,000 of his bonus for the opportunity to remain in San Diego rather than PCS across country to Norfolk, VA. Likely the *costs* of allowing the sailor to stay in San Diego are near zero for the Navy, but have a *value* of $10,000 to the sailor. In this case, the sailor gets value for his SRB dollar, and the Navy incurs a decreased retention cost.

Given the nature of economic conditions today, opinion recognizes that non-monetary incentives are a powerful tool when utilized in conjunction with monetary incentives. In a recent article, Sarah Pierce (2008) evaluates the idea when economic conditions make employers hesitant to offer raises that non-monetary incentives serve as excellent substitutes to maintain employee satisfaction and morale. Her report outlines the rationale of why employees who are at least satisfied with their current compensation level might be just as happy with "perks" as they are with increases in salary. The non-monetary ideas discussed in this article could generally be categorized as "recognition for a job well done," but rest basically in the idea that employees are satisfied if they feel they have a say in their position, and that the work they perform is valued[15]. While this report is directed toward private sector businesses, the principles are easily applied to the military services given the constraining nature of compensation alternatives available to service members.

In addition, considering the value that respondents have for individual incentives, a thorough evaluation must also include the value that individuals hold for various combinations of non-monetary incentives. It is certainly within the realm of possibility that individuals may value the combination of two incentives more or less than the sum of their individual values. The concept of the "supra-additive" or "sub-additive" values for combinations of incentives is crucial to the construct of this thesis. Both the Surface Warfare Officer study and the Enlisted Retention study elicited values for combinations of incentives from the respondents. In these studies, respondents returned valuations for the combinations of incentives that fell into each of the three categories: additive; sub-additive; or supra-additive.

To demonstrate the nature of additive, sub-additive, and supra-additive incentive valuations, Table 2 below shows the concepts of each based on the valuations an individual might place on given incentives.

[15] S. Pierce 2008, 3 Perks That Work in Lieu of Raises. *Entrepreneur.com.* accessed 21 February, 2009, from http://www.entrepreneur.com/humanresources/compensationandbenefits/article197416.html.

Table 2. Additive, Sub-Additive, Supra-Additive Demonstrated

Category	Value Individual Places on Each Incentive		Value Individual Places on Receiving Both Homeport and Geographic Stability	Additivity result
	Homeport	Geographic Stability		
Additive	10000	15000	25000	1
Sub-Additive	10000	15000	19000	0.76
Supra-Additive	10000	15000	40000	1.6

As you can see from Table 2, there are different ways in which employees may value individual incentives and combinations of incentives. As we begin to increase the number of incentives that are offered, the potential for variability across offerings increases as well. The lower limits of any combination of incentives will always be zero, as it is possible that at least one person from any representative sample will have no value for the stated combination. The upper limit however can change dramatically given the supra-additive nature by which some individuals value various incentive combinations.

The two previous reports described below are the basis for the calculations analyzing the preference elicitation problems in this thesis. The valuations expressed in these data sets are used to further understand preference variability.

A. PREVIOUS STUDIES

1. Surface Warfare Officer Study

The Surface Warfare Officer Study (SWO) was conducted as part of the MBA professional report completed by Denmond et al. (2007), and focused on efforts in the Surface Warfare Officer community to retain pre-department head officers through their second Department Head tour. Evaluation focused on the Surface Warfare Officer Continuation Pay as a retention incentive compared to combinatorial offerings that included non-monetary incentives designed to retain the needed officers by addressing quality of life factors as well as monetary incentives.

a. Methodology

The authors of this study fielded a survey asking Surface Warfare Officers what monetary bonus would be required for the officer to retain on active duty for two department head tours. The survey then inquired what portion of the bonus the officer would forego in lieu of various non-monetary incentives and combinations of these incentives. To motivate the combinatorial auction there must be some form of monetary incentive "bid" upon which to assess the value of non-monetary incentives. The foregone amounts in this study were considered "bids" in the combinatorial auction. The study assumed that the amount of bonus (in dollars) the officer would give up is the *value* the officer placed on that particular incentive.

The incentives in this study included:

Cash	Combination:	Homeport Choice and Ship Choice
Homeport of Choice		Homeport Choice and Billet Type
Ship Type of Choice		Billet Type and Ship Type
Billet Type of Choice		Homeport, Billet and Ship (all 3)

Once the valuation of each Officer's preferences was recorded in an Excel spreadsheet, each individual incentive "bid" was calculated against the theoretical costs to provide the incentive and cash required by the bidder, if the bidder were to be selected for retention. Because there was no incentive cost data, the "cost" of individual incentives was set at the 50^{th} percentile of the survey groups' valuation for a particular incentive. For example, the 50^{th} percentile valuation of the incentive "homeport choice" was $5,000. Respondents were offered this incentive if their individual stated value for the incentive was greater than $5,000. If their valuation was less, then they were not offered this incentive.

Based upon the bids placed by individual officers, the value of each officer's incentive package was derived from the combination of their cash bids and the value of their non-monetary incentive surplus. Surplus is defined as the excess value an officer would receive above the cost for the Navy to provide a particular non-monetary incentive. Table 3 below demonstrates how incentive packages were valued.

After calculating the package valuation, the packages were ranked from least to most expensive. In this case, the retention target was 117 officers, so the 117 officers with the lowest cost packages were retained.

Table 3. Package Valuation for a Notional Officer[16]

Bid for a Notional Officer				
	Bid	Costs	Difference	Awarded
Base Bonus Required (min to retain)	**150000**			
Homeport	20000	5000	15000	
Ship Type	10000	0	10000	
Billet	10000	1250	8750	
Homeport/Billet	25000	10000	15000	
Homeport/Ship	**50000**	**7500**	**42500**	Yes
Ship/Billet	20000	5000	15000	
Homeport/Ship/Billet	50000	15000	35000	
Sabbatical	**10000**	**5000**	**5000**	Yes
Telecommuting	**20000**	**5000**	**15000**	Yes
Geographic Stability	**10000**	**5000**	**5000**	Yes
Inc. Cost to the Navy:	7500 + 5000 + 5000			
	22500			
Adjust Bonus:				
Bonus Bid minus Incentive Valuations for awarded incentives				
	150000 - 50000 - 10000 - 20000 - 10000			
	60000			
Effective Cost to the Navy is: Adjusted Bonus plus Cost of Incentive				
	82500			
If the cost of the First Excluded Incentive Package is 101,250, the adjusted cash bonus is:				
Adjusted Cash Bonus	101250 - 82500 + 60000 =			**78750**
Now add new adjusted cash bonus to incentive value for the officers' incentive value				
Total package value is	78750 + 50000 + 10000 + 20000 + 10000			
Total package value is	**$168,750.00**			

[16] Denmond et al., "Combinatorial Auction Theory Applied," 78.

b. Significant Findings

This study estimated a significant cost savings to the Navy to retain the required number of Surface Warfare Officers. Of the required 117 officers targeted in their auction, the total cost to retain using purely monetary incentives was over twenty million dollars. By combining monetary and non-monetary incentives, the Navy was able to provide the average officer $60,000 more in incentive *value* to the officer, at a savings of more than eight million dollars to the Navy. The combinatorial auction price averaged a $73,000 savings per officer. The Navy saved money and the officer gained value from his continuation package over the monetary only offering.[17]

2. Enlisted Retention Study

The Enlisted Retention Study was conducted to continue the string of research addressing non-monetary incentives as part of a retention effort in the Navy. The author fielded a survey to two ratings of enlisted service members formatted in a similar fashion as the surface warfare officer Study. The methodology of this study followed very closely the initial development of the surface warfare officer study, but used slightly different cost estimations in the excel model. This will be further explained in the methodology section below.

a. Methodology

As indicated, the data for this survey was obtained in a similar fashion as the Surface Warfare Officer study. Of note, the available incentive offerings were expanded and two groups of combinations, each involving three incentives were available rather than the one offering of three incentives in the SWO survey.

Incentive offerings included:

Homeport	Professional Certification in field/trade
Platform	Compressed Workweek
Billet	Transferability of GI Bill benefits to family

[17] Denmond et al., "Combinatorial Auction Theory Applied," 67.

One Year Sabbatical	Single barracks room while assigned to ship
Telecommuting In-port	BAH while assigned to ship
Geographic Stability 2 tours	Geographic Stability 3 tours
Lump Sum SRB	

Combinations:
- Homeport / GeoStability 2 tours
- Homeport / Compressed Workweek
- GeoStability 2 tours / Compressed Workweek
- Homeport / GeoStability 2 tours / Compressed Workweek
- Lump Sum SRB / Telecommuting
- Lump Sum SRB / Homeport
- Homeport / Telecommuting
- Lump Sum SRB / Homeport / Telecommuting

To differentiate her study, as well as gain other additional information, Zimmerman simulated the data from survey respondents using three different approaches to structuring incentive packages: Monetary only, Universal Incentive Package (a one-size fits all incentive package), and Combinatorial (individualized incentive packages). Each model was simulated as a reverse second price auction. Also, each model was simulated at the 25, 50 and 75% retention levels.

The first calculated model (monetary only) was used to assess the cost to achieve various retention levels using purely cash retention incentives. As expected, the bonus received per sailor increases as the retention level increases from 25% to 50% to 75%.

The Universal Incentive Package was more difficult to motivate. This model was used to determine the utility individuals gain from a standardized incentive package offered to all service members. To effectively determine which non-monetary incentives to include in the universal incentive package, the analysis calculated the cost for each non-monetary incentive (NMI) where the total sailor value equaled the total cost to provide that NMI to all service members. This cut-off occurred at approximately the 75^{th} percentile in the service member's value distribution; this was considered an adequate approximation for purposes of this model. Only NMI's whose costs were less

than the 75% percentile of the value distribution were offered in the universal incentive package. The results of each bid were then calculated in a similar fashion as described in Table 2 above, and ranked accordingly.

The Combinatorial Retention Auction Mechanism was motivated in a similar manner as the SWO study. The cost assignments in this study were based on two methods. The first simulation, termed VP(AP), or Variable Price-All Positive assumed that NMI costs fell somewhere in the positive range of the values submitted by the survey respondents, ranging from the lowest to the highest positive value reported. The second simulation, termed VP(HP), or Variable Price—High Positive, assumed that NMI costs fell somewhere in the upper half of the range of positive values reported. For both scenarios, 1,000 trials were simulated (using Crystal Ball simulation software) selecting different costs from the relevant range for each NMI.

In each of these cases, again, the sailor was only offered a given incentive if his valuation for the incentive was greater than the Navy's cost to provide it. Each package was calculated in the manner described in Table 2 above. The results were ranked accordingly.

b. Significant Findings

Findings from the Enlisted Retention study are quite impressive, and significant. First, the combinatorial auction selecting personalized portfolios of retention incentives certainly offers the opportunity to decrease retention costs over the current system. As well, sailors received the optimal mix of monetary and non-monetary incentives to meet their personal needs and situation, resulting in "happier" sailors.

Based upon these assumptions, and for the given set of survey respondents, Zimmerman (2008) demonstrated that CRAM provides significant potential cost savings for the Navy, on the order of 30% or more. Her results also indicate that the highest cost savings occur at the highest retention levels, which intuitively is accurate.

While both studies show significant cost savings using CRAM to personalize individual incentive packages, they also show there is substantial variability

in preferences. This analysis will examine the data contained in these studies to further evaluate the nature of variability over individual preferences, across NMIs, across groups, across people within a group, and across combinations of NMIs for an individual.

B. VARIABILITY ACROSS NON-MONETARY INCENTIVES

1. Variability across Individual Non-monetary Incentives

Variability is arguably the source (and salvation) of the difficulties present in the CRAM as modeled in the identified studies. In the enlisted retention survey, there is tremendous variability in the valuation of individual non-monetary incentives across respondents. In the Surface Warfare Officer survey, similar variability is also present, but the patterns of variability are different.

Figure 1 below shows the mean (average) and median (middle value) for each of the NMIs offered in the enlisted study. Note that some offerings such as homeport preference are highly valued (high mean) and highly sought (high median). Others such as a single barracks room while stationed aboard a ship held almost no value (low mean) and were not highly sought (low median). Finally, transferability of the GI Bill benefits showed a third option of highly valued (high mean), but not highly sought (low median). It is the difference in how incentives are valued that makes the valuation elicitation problem difficult to quantify.

The difference in average valuation of incentives within a population is also important to the nature of this thesis because it implies that different NMIs will have different values within a population; the choice of NMIs is important. Figures 2 and 3 below show the average valuation of NMIs by the group of respondents from the enlisted retention survey.

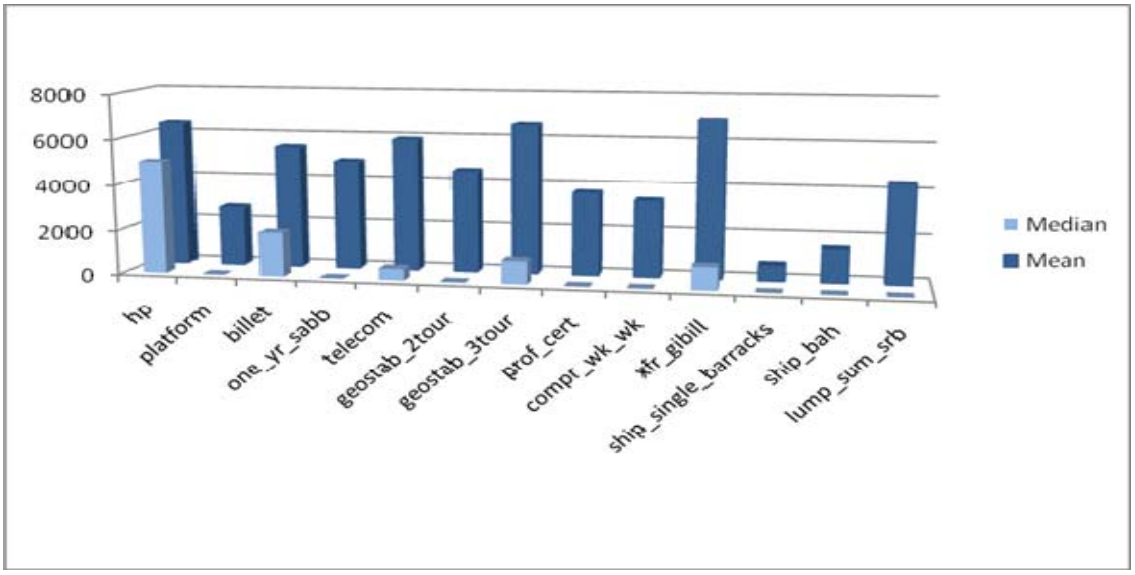

Figure 1. Variability Across Individual NMIs

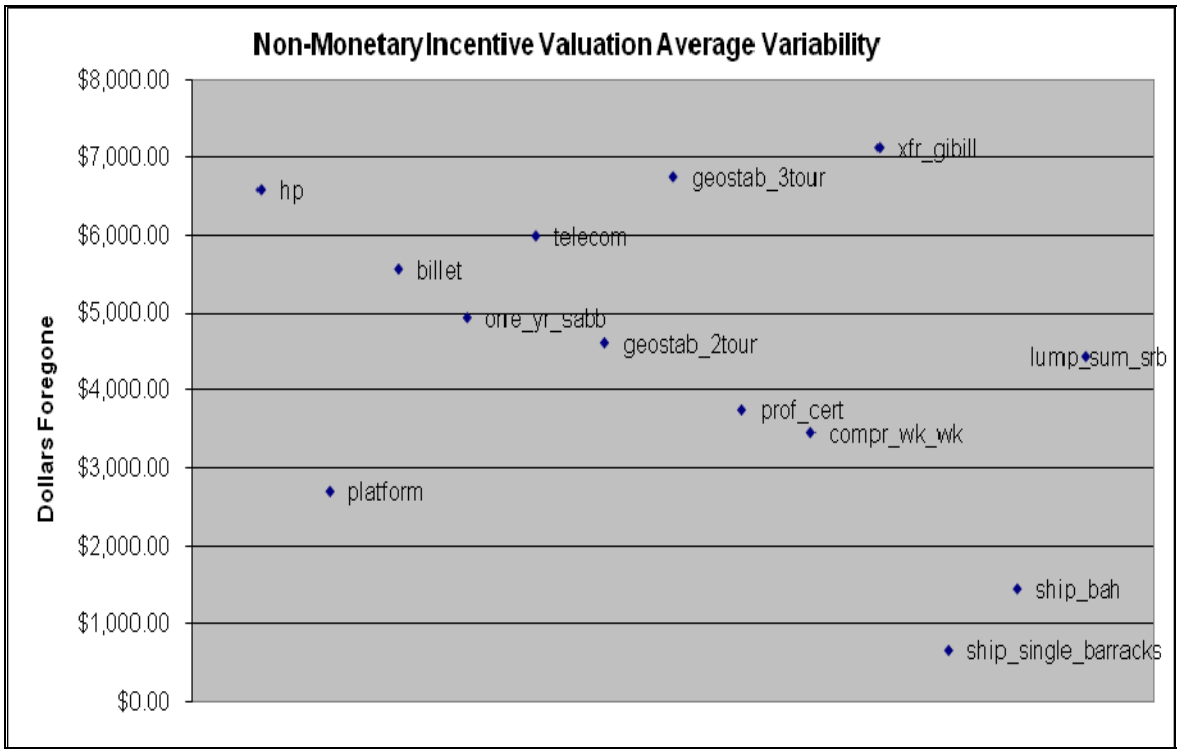

Figure 2. Variation Across Average Non-monetary Incentive Valuation

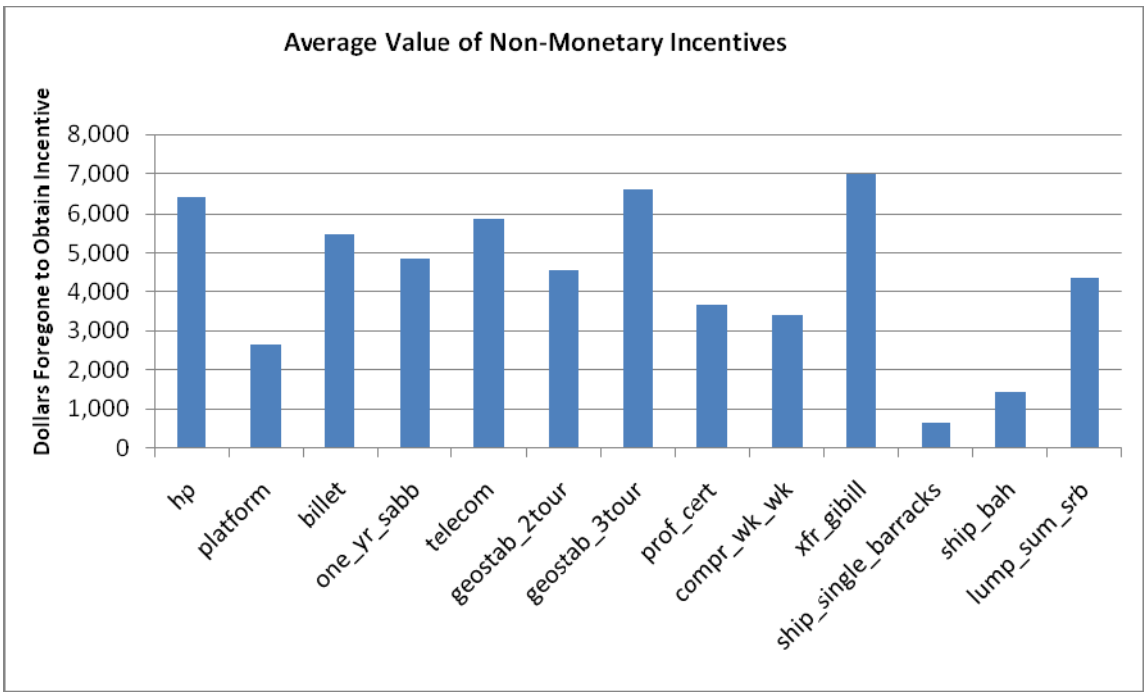

Figure 3. Average Value of Non-Monetary Incentives

As demonstrated, there is wide variability across the average value service members place on different non-monetary incentives. While service members would on average give up over seven thousand dollars of their SRB for the option of transferring their G.I. Bill benefits to their dependents, they would only give up just over six hundred dollars for the option of having a single barracks room in port while stationed aboard ship. Within each of these examples there are individuals who would give up significantly more than the average for each of these incentives. While variability of this magnitude could be viewed as an implementation difficulty, it is this variability which offers great potential in meeting individual sailor's requirements in personalized incentive packages; this is viewed as a positive attribute in this thesis.

C. VARIABILITY ACROSS POPULATIONS: OFFICER VS. ENLISTED

There are several ways to consider the variability in valuation for incentives that exists between different groups. In the case of the SWO survey and Enlisted Retention survey, two well defined groups were questioned regarding similar incentives, under similar circumstances.

Both the enlisted and officer groups were questioned regarding their valuation of the following incentives: choice of homeport; choice of platform/ship type; and choice of billet. Table 4 and Figure 4 below show the difference in valuation for the non-monetary incentives common across the two studies. The valuations listed are the average amount of cash the respondent would sacrifice to obtain the indicated incentive. It is easy to identify the differences in average valuation given to the three incentives by officers and enlisted members and the magnitude of the difference. On average, the officer respondents have a higher value for non-monetary incentives than their enlisted counterparts.

Table 4. Difference in Average Valuation of Incentives by group. Officer vs. Enlisted

Average Valuation For Incentive:			
Group	Homeport	Ship Type	Billet
SWO	10,693.71	3,724.49	7,279.95
Enlisted	6,432.73	2,644.55	5,450.34

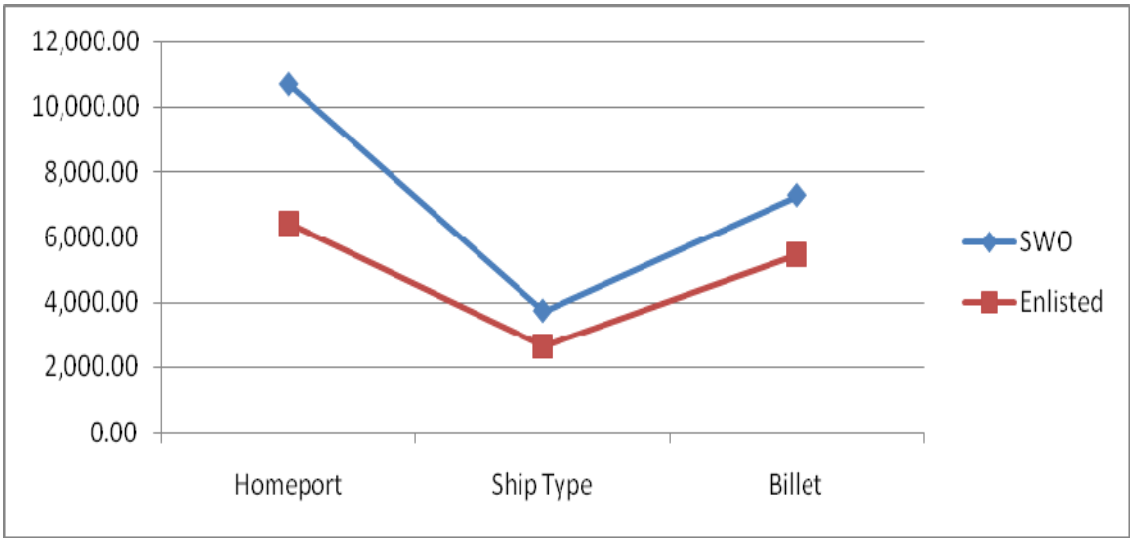

Figure 4. Difference in Average Valuation of Incentives by group. Officer vs. Enlisted

These graphs demonstrate how different groups may value incentives at different levels or in different ways. The variability shown here is another layer of uncertainty surrounding the way in which incentives are valued, and again, necessitates an adequate method of dealing with the variability inherent in the preference elicitation problem.

D. VARIABILITY WITHIN A POPULATION

1. Variability across the Averages of Multiple Non-monetary Incentives

The variability in the valuation of non-monetary incentives within a population was previously described in section B. Adding yet another dimension to the variability equation is the idea that variability is also seen in the valuation for an NMI by members within a population. There are certain non-monetary incentives that, as a whole this group of survey respondents values much less than others. In consideration of the nature of variability, this is expected. In addition, it is important to note that the variation in NMI's preferences across individuals is also important.

An excellent example of this variability is demonstrated by the responses from the Enlisted Retention Survey[18] and the range of valuations offered for a guarantee of homeport preference. Figure 5 below demonstrates the variability of results from question 5A of the Enlisted Retention Survey, asking the amount of a selective reenlistment bonus the respondent would forego to guarantee their homeport of choice.

[18] Zimmerman, "Integrating Monetary and Non-monetary Reenlistment Incentives," 131-140.

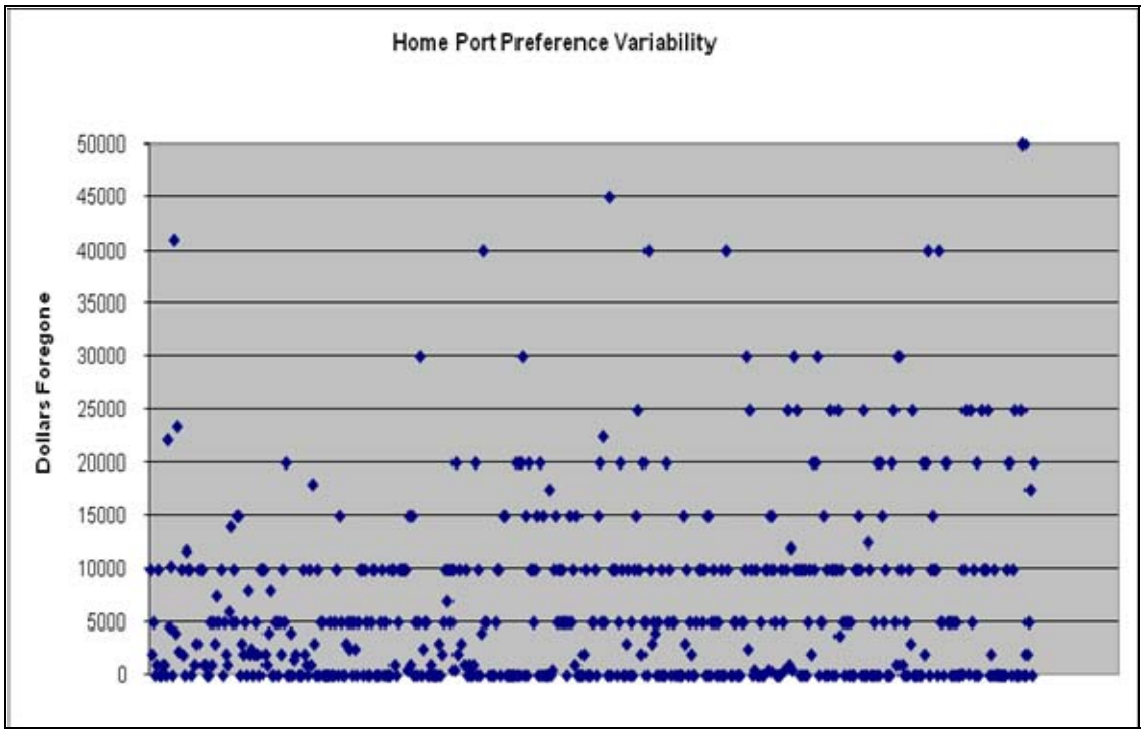

Figure 5. Home Port Preference Variability

Obviously there is significant variability in the value that the 531 respondents place on the opportunity for homeport preference. The values given range from zero (no value) to fifty thousand dollars (high value). A scatter diagram of each non-monetary incentive offered as part of this research would offer a similar view of the nature of valuation across individual incentives. The magnitude of the variability in valuation differs, but the nature of the variability is consistent.

Valuation as an indicator of personal preference is an excellent tool that can be utilized to develop incentive packages that not only take advantage of individual preferences, but also allow personnel planners to develop programs that more fully meet the desires and expectations of the individual sailor. However, exploiting these differences requires individualized incentive packages as opposed to a universal incentive package.

To more fully address this point let us reconsider the case of our San Diego sailor:

Recall he is willing to forego $10,000 of his bonus to remain in San Diego. The sailor's shipmate on the other hand joined the Navy to see the world and really doesn't have a preference for choosing a home port. The shipmate would prefer to choose a specific type of ship he feels has a heightened operational tempo, furthering the likelihood of his "seeing the world." The shipmate might hold no value for home port preference, but would forego his own cash bonus to choose his ship type and increase his own utility (seeing the world).

The graph above, and subsequent explanation and example, are representative of the type of variability one might expect from a group of people. Some respondents might place high value on a given incentive, while others might place less value on the same incentive. The variability in how people value individual incentives is one important element of the variability problem.

E. VARIABILITY IN STANDALONE VS. COMBINATION INCENTIVES

Another complicating factor to the already murky preference/valuation elicitation problem occurs when combinations of incentives are offered for consideration. You may recall that Chapter III defined the concepts of additive, sub-additive, and supra-additive preferences. Additivity is measured by dividing the stated valuation of the incentive combination by the sum of the stated valuations for each of the incentives in isolation. Measuring the additivity of incentives in this way, a ratio of 1.0 indicates that individual incentives are perfectly additive. Less than 1 or greater than 1 indicates sub-additive or supra-additive valuation respectively. This section discusses these concepts in relation to the SWO and Enlisted Retention studies.

It is important to know how individuals value combinations of incentives. From an implementation standpoint, knowledge of which individual and combinations of incentives offer the best response, and how they are valued, is vital information. At the minimum, if combinations of incentives are valued more or less than individual incentives, a policy can be implemented to support the desires of those who will

ultimately be affected by the policy. But, once again, variability in the way individual versus combination incentives are valued is present.

Variability as it applies to several different situations has been addressed in preceding sections. Table 5 below shows the relative additive, sub-additive, or supra-additive nature of the valuation of incentives returned from the Enlisted Retention and Surface Warfare Studies. It is important to note the difference in the relative additive nature of each combination in the enlisted study, and contrast these with the results from the SWO study.

Table 5. Variability in Standalone versus Combinations of Incentives

Enlisted Study			
Two Incentive Combinations			Three Incentive Combo
HP & Geo	HP & CWW	Geo & CWW	HP, GEO & CWW
0.571	0.511	0.569	0.564
LumpSRB &Telecom	LumpSRB & HP	Telecom & HP	LumpSRB, Telecom & HP
0.443	0.541	0.416	0.439
SWO Study			
Two Incentive Combinations			Three Incentive Combo
HP & Billet	HP & Ship	Ship & Billet	Combination all 3
0.905	0.859	0.742	1.060

Easily identifiable are the differences in valuation that respondents offered for various two and three incentive combinations. These results indicate that overall, enlisted members value combinations of incentive much less than they value the sum of individual incentives. Even though the overall results are sub-additive, there were numerous individual cases in which the results were supra-additive.

Take the case of respondent 625356940. The sum of his valuation for the individual incentives Home Port, Geographic Stability (2 tours), and Compressed Work Week were ten thousand, twenty five thousand, and five thousand dollars respectively. If he were offered the combination of all three incentives he would have given up seventy five thousand dollars, or more descriptively, the entirety of his bonus. Obviously his valuation of NMI's was supra-additive.

In contrast to the enlisted results, officers seem to value combinations of two incentives at a higher level than the enlisted group, but preferences are not quite at fully additive; in contrast, the three incentive combination was valued as slightly supra-additive.

Once again, you will note the variability that is present not only among individuals, but also between the two groups. These differences compound the preference elicitation problem.

F. CHAPTER CONCLUSION: WHAT DOES IT ALL MEAN?

In conclusion of Chapter III, it is important to note the sources of variability in personal preferences across NMIs. To begin, this chapter demonstrated that values differ significantly across NMIs. Continuing on, variability in the valuation of incentives across groups was demonstrated by contrasting average valuations from the officer and enlisted groups. Third, variability in the valuation of incentives across individuals within a group was demonstrated. Finally, the variability that is present between individual incentive offering and combinations of incentives was addressed. The following chapters will further address this variability, particularly sub- and supra-additivity within combinations of incentives to determine its significance and how this variability affects preference elicitation within the CRAM.

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IV. AUCTIONS AS A FORCE-SHAPING TOOL

A. INTRODUCTION

Auction-based retention mechanisms are an evolving aspect of military personnel management efforts. While the context of this research focuses on retention auctions there are multiple other opportunities to use these same mechanisms in other areas. This chapter describes the current selective reenlistment bonus system and how SRBs are determined. Continuing on, this chapter also identifies types of auctions and their application to the retention picture. Finally, it discusses current and recent Department of Defense uses of auction mechanisms, as well as the driving forces for using auction mechanisms as force-shaping and retention tools.

B. TRADITIONAL SELECTIVE REENLISTMENT BONUS VERSUS AUCTION-BASED BONUS

1. Selective Reenlistment Bonus

Zimmerman (2008) provided a thorough review of the way in which SRBs are currently determined by the Navy. To paraphrase her assessment, the Navy must determine, and then pay, the SRB amount required to entice the most reluctant sailor that must reenlist to meet end-strength requirements.[19] While this method of establishing SRBs will effectively retain the required number of sailors, it also results in the Navy paying more willing sailors (even those who would have reenlisted for no bonus at all) the same bonus as the "most expensive" or reluctant sailor. This process results in the Navy paying economic rent for sailors that would have stayed for less cost. The current system of selective reenlistment bonus setting does not produce the most cost effective SRB system and potentially increases the Navy's retention cost over other mechanisms.

Figure 6 below demonstrates the two significant problems associated with current SRB determination. In this example the Marine Corps wants to retain 3,000 marines. The first problem occurs in determining the correct bonus to retain the desired number of

[19] Zimmerman, "Integrating Monetary and Non-monetary Reenlistment Incentives," 10.

Marines. If the SRB is set too low, the Marines will fall short of their retention goal. If the SRB is too high, they will overshoot their retention goal and be forced to suspend reenlistments.

The shaded area represents the second problem associated with a one price SRB offering, the "economic rent" that the Marine Corps has to pay to retain the desired number of Marines. Approximately ¼ of the Marines retained would have reenlisted for no bonus at all, yet they receive the full $7,000 bonus. The excess bonus that is paid to all Marines below the 3,000th Marine is money that potentially could be recouped if the retention mechanism were motivated in some other fashion.

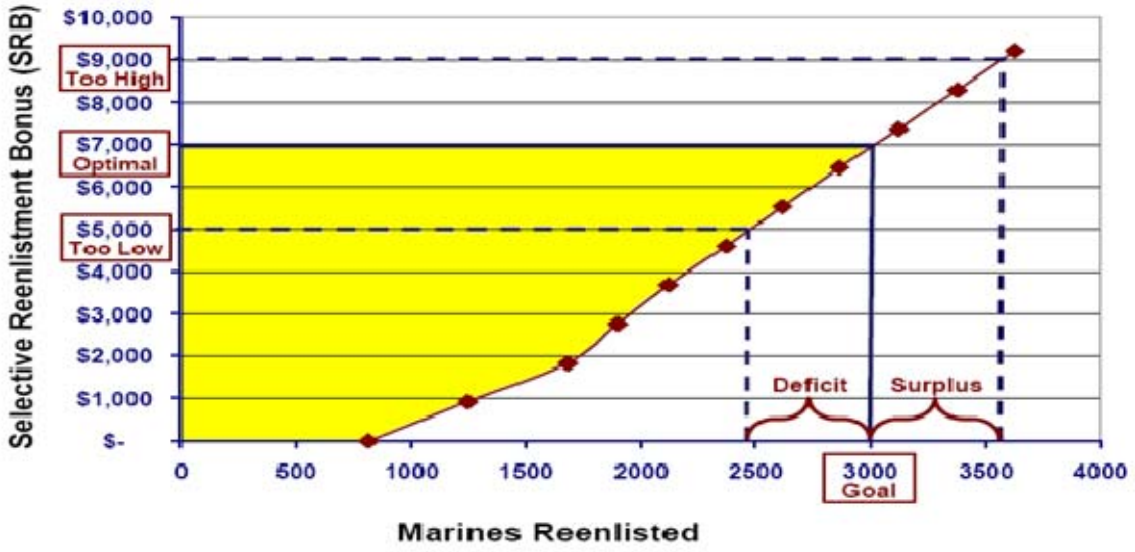

Figure 6. Problems with SRB Determination[20]

2. Auction Variations

As described early in this thesis, evaluating auction-based bonus systems is an area of research whose focus is limiting the amount of excess bonus offering and therefore retaining the required number of sailors at a lower overall cost. An auction is defined as the sale of something in which potential purchasers bid against one another for the right to buy the item. There are several types of auction mechanisms that can be

[20] Peter J. Coughlan, "Mechanism Design for Defense Management: A Research Agenda and Representative Illustration," (lecture, Naval Postgraduate School, Monterey, CA, 20 November 2008).

utilized for retention purposes. The type of auction format chosen depends on how the program is to be administered. For the purposes of this thesis we will discuss auctions in terms of forward and reverse auctions, and first and second price auctions.

a. Forward Auctions

Forward auctions are similar to the auctions carried out on websites such as Ebay. Generally, there is a single seller and multiple buyers. An item is offered for sale and multiple potential purchasers bid on the item, eventually driving the price of the item up. This type of auction is beneficial for the seller who is seeking to get the highest price for his single or multiple items for sale.

b. Reverse Auctions

Reverse auctions occur when a buyer seeks a good or service and multiple sellers bid on the opportunity to provide the good or service. Under this type of format, it is expected that the single buyer receives multiple offers and can obtain the good or service at the lowest possible price, given market conditions at the time.

c. First Price Auctions

In first price auctions, the winner is the person with the highest bid and the winner pays the amount that he bid. This is generally the type of auction people envision when considering auctions. First price auctions have utility for the seller in assuring the highest possible bid is achieved in a given buyers market.

d. Second Price Auctions

The second price auction varies slightly from the first. The difference in this auction is that the person who bids the highest amount wins the auction, but pays the second highest bid rather his highest bid.

Figure 7 below demonstrates the relationship of forward and reverse auctions to market activity. If we consider sailors as sellers of their labor services, and multiple sailors are willing to sell their labor service, then market forces will take over and drive down the price paid by the buyer (Navy).

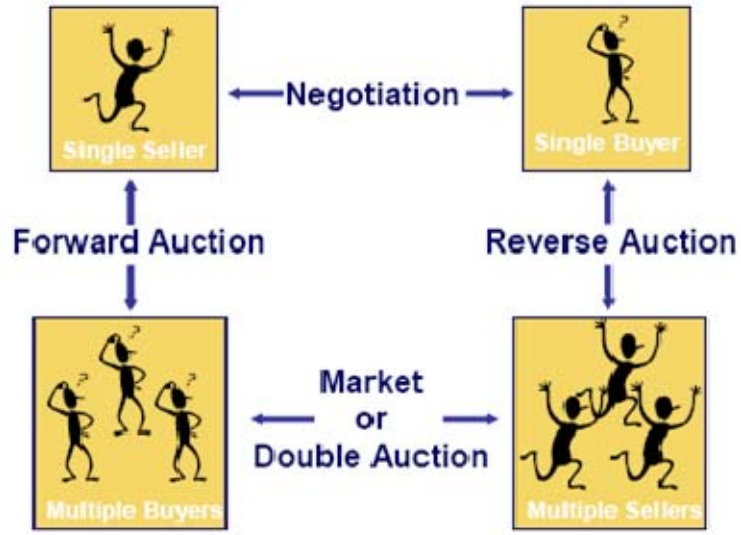

Figure 7. Auction Variations and Their Related Market Forces (From Coughlan, Introduction to Economics)[21]

e. Sequential (Open Outcry) Auctions

In sequential or open outcry auctions, all participants or their agents are present, physically or virtually, during the auction. Participants continue to bid as long as they are willing to submit a price that beats the current best offer. The auction ends when no one is willing to better the standing offer.

f. Simultaneous (Sealed-Bid) Auctions

In simultaneous or sealed bid auctions, all participants have a window of time in which they can submit a single bid representing their best offer. All bids are open simultaneously and the winner is declared based on the best submitted offer. Participants do not need to be present when the bids are opened.

Given deployments and operational tempo for military personnel, sealed-bid auctions are more appropriate than open outcry auctions for determining retention bonuses. Sealed-bid auctions can be conducted in either a first price or second price

[21] Peter J. Coughlan, "Introduction to Auction Economics," (lecture, Naval Postgraduate School, Monterey, CA, 29 November 2004).

format. Gamesmanship is a part of the bidding process in first price sealed bid auctions, as bidder will try to determine how much they can adjust their bid to increase the surplus they capture while still winning the auction. Second price sealed-bid auctions encourage the bidder to bid his actual willingness to pay; there is no potential to gain by misrepresenting their willingness to pay.

g. Single Winner Auctions

In a single winner auction there is only one item to sell or buy, so there is only one winner.

h. Multiple Winner Auctions

Multiple winner auctions offer an opportunity, as the name implies, for multiple bidders to win an auction. In the case of retention auctions, the sellers who are chosen for retention would be the winners.

3. Department of Defense Experience with Auction Mechanisms

The Department of Defense has some experience utilizing auction-based mechanisms to achieve personnel management goals. One recent example includes the program of Assignment Incentive Pay. AIP utilizes a form of auction to achieve its personnel management objective.

Similar to the difficulties the Navy has experienced in retaining the sailors with the right skills has been the difficulties the Navy has experienced in encouraging sailors to accept certain "less desirable" assignments. The reluctance to accept may be based on type of duty, length of tour, geographic location, or any other of a number of individual preferential factors.

To combat the difficulties of filling less desirable billets, in 2003 the Navy began to utilize a program called Assignment Incentive Pay (AIP). Under AIP sailors who hold the correct Navy Enlisted Classification (NEC), are in the correct sea/short rotation, and are more willing to accept less desirable duty in exchange for additional compensation can apply and "bid" for the duty. If accepted, the amount bid is paid monthly as extra pay.

AIP is in essence a reverse auction. There are multiple bidders willing to accept the difficult to fill billet, but only the sailor who meets all requirements and delivers the lowest bid will be accepted. This is a reverse, first price sealed bid auction with a single winner. This type of setup results in market forces determining how to address the shortfall. The Chief of Naval Personnel at the time AIP was introduced, Vice Adm. Gerry Hoewing, described AIP as follows: "We are taking advantage of marketplace dynamics to get the talent where we need it most, and that innovative approach is making us a much more capable and agile force as a result."[22]

In regards to guidance the Department of Defense has been given related to auctions, the 10th Quadrennial Review of Military Compensation has taken a strong position related to the use of auctions as a potential force-shaping tool. One particular recommendation relates to offering bonuses to Medical Department Professionals. To paraphrase the QRMC recommendation, auctions should be a part of everyday business practices as a method of retaining the right mix of Medical Department Personnel in a cost-effective manner.[23] While this citation to the QRMC specifically is looking at the opportunity to fill billets which have been traditionally more difficult to fill, the idea remains that offering the opportunity for auction based mechanisms is appropriate.

[22] Chief of Naval Personnel Public Affairs Release, "Navy Offers Assignment Incentive Pay For Billets In Guam And Sasebo," Navy.mil website, accessed 19 February 2008 at http://www.navy.mil/search/display.asp?story_id=12187.

[23] U.S. Department of Defense: Office of the Assistant Secretary of Defense. (February 2008). Tenth Quadrennial Review of Military Compensation, Volume II. Washington, DC: Publisher. 81.

V. ADDRESSING VARIABLE VALUATIONS I: THE COMBINATORIAL RETENTION AUCTION MECHANISM

Addressing the variability in valuation of non-monetary incentives is the focus of this research. Thus far, this thesis has described the multiple sources of variability that are present in personal incentive valuations. This chapter demonstrates various methods of addressing variability and, where possible, compensating for variability.

There are two options for implementing a non-monetary incentive package discussed in the previous research on military retention bonuses: the Universal Incentive Package (UIP) and the Combinatorial Retention Auction Mechanism (CRAM). While both approaches have benefits, CRAM arguably is better able to address variability in incentive valuations. To fully understand the benefits associated with CRAM, the two methods are evaluated here.

A. UNIVERSAL INCENTIVE PACKAGE

Recall that the basic idea behind implementing non-monetary incentives as a form of compensation relies on a basic understanding of how the incentives are valued by the target population. The Universal Incentive Package offers a "one size fits all" approach to non-monetary incentive implementation. Basically the UIP attempts to determine how the target population values various NMIs, then includes the most attractive incentives as part of overall universal retention package. If overall the population values an incentive more than it costs to provide, then that incentive is cost effective as part of the retention offering. In addition to the non-monetary incentive package, members receive a cash bonus, which is either pre-determined or determined via auction.[24]

While the Universal Incentive Package offers several benefits to both the Navy and service members, it also has several deficiencies. The primary deficiency of the UIP is that some service members end up receiving incentives for which the Navy's cost exceeds their value. This action ends of costing the Navy more than it benefits the sailor. The second major problem with UIP is that the package may not include some incentives

[24] Coughlan presentation "Mechanism Design for Defense Management," 20 November 2008.

that would otherwise entice service members to retain. Figure 8 shows the benefits and waste generated by the UIP, as well as the benefit potentially gained under CRAM (explained in section B) that is not achieved by UIP. In terms of variable incentive valuations, the UIP cannot compensate for variations across individuals within a population. UIP can select the most attractive NMIs and tailor incentives to different populations, so it can compensate for differences in valuations across NMIs and across populations, but UIP cannot compensate for variability that is present in how individual sailors value incentives of for variability in valuations across combinations of incentives.

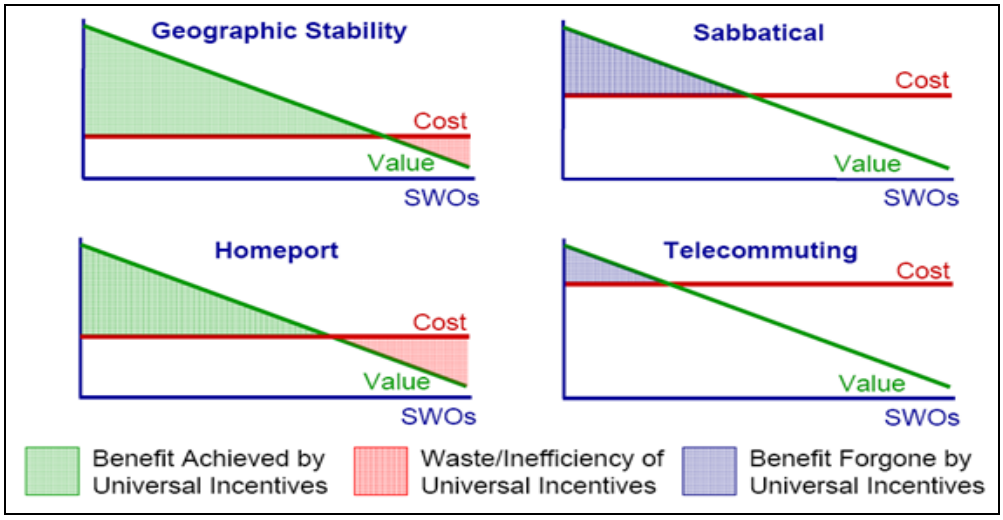

Figure 8. Limitation of a Universal Incentive Package[25]

B. COMBINATORIAL RETENTION AUCTION MECHANISM BASICS

The combinatorial retention auction mechanism seeks to compensate for the variability that is present in valuation of incentives:

- Across individual incentives
- Across various populations
- Within a given population
- As standalone or in combinations

[25] Coughlan presentation "Mechanism Design for Defense Management," 20 November 2008.

The CRAM is a reverse, multiple winner, second price, sealed-bid auction. The "combinatorial" component of CRAM combines non-monetary and monetary incentives as part of the auction process. Service members bid on incentive packages that consist of: (1) A monetary requirement; and (2) Non-monetary incentive valuations.

Each service member offered retention under CRAM receives an individualized package of a monetary bonus and non-monetary incentives based upon their bid. Their bid is derived from the valuation they place on non-monetary incentives. The Navy's total cost of this package is based upon a second price auction.

Table 3 in Chapter III (Package Valuation for a Notional Officer), outlined the way in which CRAM "bids" are determined. The individual respondent indicates the minimum cash bonus required to remain on active duty for a specified period of time. For each incentive that the bidder values, the amount of cash they are willing to forego is indicated. If the respondent values an incentive more than it cost to provide, that incentive is included in the retention package. The set of lowest-cost service members to retain is determined.

Each service member retained under this method receives:

- The set of non-monetary incentives included in their bid
- Cash bonus equivalent to the total cost of the first-excluded package bid minus the cost of their non-monetary incentives.

The benefits of CRAM are significant. Under this method, bidders receive this highest possible value by "truthful revelation" of their preferences. While other auctions or surveys encourage members to overstate their valuation of incentives, CRAM does not. Under CRAM, individuals should bid what they are truly willing to give up for an NMI. The risk of overbidding an incentive is that they might get stuck paying more for an incentive than it is actually worth to them. If they underbid an incentive, they risk not being retained when they would like to be retained. Neither scenario is supportive of being less than honest in their incentive valuations.

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VI. ADDRESSING VARIABLE VALUATIONS II: PREFERENCE ELICITATION WITH INCENTIVE COMBINATIONS

A. THE COMPLEXITY OF PREFERENCE ELICITATION WITH INCENTIVE COMBINATIONS

In considering the CRAM methodology for determining personalized retention incentives for sailors, the structure of the auction process is extremely important if the results are to be considered valid. As with any auction, to be valid, the auction itself must be easy to use and not overly burdensome or time consuming to participate.

As discussed in the previous chapter, the "full information" variant of the CRAM, in which each bidder provides his valuation for each possible combination of non-monetary incentives, fully compensates for all classes of variability in valuations identified in this thesis. In particular, the full elicitation of valuations allows the CRAM to completely incorporate any variation between valuations of NMIs when offered alone vs. when offered as part of a combination of incentives.

An important consideration that must be addressed in developing any mechanism that might be used to elicit NMI valuations is what this thesis identifies as incentives to the 2^n problem. For example, if the CRAM were indeed to elicit a valuation for every possible combination of incentives, each bidder would have to submit a minimum of 2^n bids, where the superscript (n) is the number of incentives offered.

In the case of the SWO study, the valuations of three particular incentives were explored in detail, therefore 2^3 combinations of these three incentives were possible, and a minimum of 8 questions must be asked. In this case, the survey addressed more than just those three incentives, however, and asked a total of 12 questions related to the valuation of incentives.

The Enlisted Retention survey took a different approach to addressing the valuation elicitation problem. This survey addressed 13 separate incentives, but only addressed two groups of three incentives in combination. The resultant survey asked a

total of 25 questions related to valuation solicitation. The author chose to forego results for every combination of incentive, choosing not to elicit valuations for several of the incentives combinations.

The complexity of the 2^n problem should be readily apparent. If the Navy were to consider a program that offered 10 different non-monetary incentives, the minimum number of questions required to value all incentive combinations would be 1,024. Obviously this would be prohibitive from an implementation standpoint. From a validation standpoint, it is intuitive to think that the results would not be trustworthy because the burden of completing such a questionnaire would force most individuals to just "give up" without answering all questions or providing conflicting answers. Additionally, such a process would require the respondent to keep track of or recall the valuations he/she placed on each incentive and make a conscious judgment on the valuation he offered for each individual and combination of incentives.

B. THE (LIMITED) CONSEQUENCES OF ASSUMING ADDITIVE VALUATIONS

This research has addressed many of the aspects associated with variability in preference for and valuation of NMIs as part of the CRAM. Information requirements to the 2^n as described above reflects the most troubling problem associated with attempting to elicit a valuation for each and every combination of incentives to consider as part of a combinatorial retention auction.

One possible simplifying alternative to eliciting valuations for each and every combination of incentives would be to only elicit the valuation for each NMI individually and assume that the valuations offered by each respondent were additive in nature, if included as part of an incentive combination. For example, the mechanism could ask for each sailor to submit a valuation for some non-monetary incentive A – denoted Value(A) – as well as a valuation for some other non-monetary incentive B – denoted Value(B) – but would simply assume that the valuation for these two incentives in combination was simply the sum of the "stand-alone" valuations. In other words, the mechanism would assume Value(A+B) = Value(A) + Value(B).

From an implementation perspective, the advantage of making this assumption should be readily understood. For 10 non-monetary incentives, for example, each bidder would only need to submit 10 valuations as opposed 1,024 valuations as previously calculated. As with any policy, the greater the ease of implementation, assuming the value of the policy is adequate, the greater the likelihood of compliance and buy-in. Of concern at this point is the question of what might be lost or given up if the valuation of preferences is assumed to be additive.

Related to the CRAM, there are two potential concerns with assuming valuations are additive, however. The first occurs when the respondents' valuations are assumed to be additive, when in actuality there valuations are *supra-additive* – when Value(A+B) > Value(A) + Value(B) – and the retention outcome is altered as a consequence of this assumption. The second potential concern occurs when the respondent's valuations are assumed to be additive when actually they are *sub-additive* – when Value(A+B) < Value(A) + Value(B) – and the retention outcome is again altered as a consequence of this assumption.. Each of these cases is addressed individually below. As will be demonstrated, the presence of super-additive or sub-additive preferences only influences the outcome of the CRAM in certain very particular scenarios.

1. Implications of Assuming Additive Valuations, When Actual Valuations are Supra-Additive

The first case of potential concern relates to potentially failing to retain a low cost bidder as a result of assuming additive valuations when the individual's true valuation of a combination of NMIs is actually supra-additive (the NMIs are complementary or synergistic). As you may recall, an individual's retention cost in the CRAM is inversely related to the surplus that he or she has for a given incentive or combination of incentives. The surplus reflects the individual's value minus the cost of the incentive or combination. If we assume that a bidder's value for a given combination of incentives is additive when in actuality their valuation is supra-additive, we are in essence understating their surplus (and thus overstating their overall retention cost) when determining which bidders the CRAM will retain. It is possible, therefore, that a sailor might not be retained by the mechanism when in fact he or she would be willing to retain at a cost less than the

"cutoff cost" (i.e., the total cost of the first-excluded package) associated with the set of retained sailors. This could potentially also increase the Navy's retention costs.

The first three scenarios in Table 6 below illustrate cases in which a bidder holds significant supra-additive value for the combination of incentives A and B, but we assume his value is only additive. Recalling the methodology related to valuing retention packages, packages are ranked based upon surplus value. Surplus value is determined by willingness to give up cash bonus minus the incentives' costs to provide. With supra-additive error, we are underestimating the actual surplus a bidder has for a combination of incentives. In this case, the bidder could potentially not be retained by assuming additive values, when in fact the Navy would have been better off and the bidder would have gained value if he or she were retained.

Scenarios 1 and 3 of Table 6 below are not problematic. In these cases, based upon the assumption of additive valuation, those who wish to be retained are offered retention, and those who do not wish to be retained are not offered retention. (The value to retain is above or below the cutoff cost, respectively). Scenario 2 of Table 6 demonstrates the potential of underestimating the actual surplus of the bidder for the given combinations. In scenario 2, under an additive valuation assumption, the cost to retain is 36, when the bidder could actually be retained at 26. In this case the *assumed* cost to retain is above the cutoff of 30 and retention is not offered when the bidder actually could have been (and would want) to be retained.

2. Implications of Assuming Additive Valuations, when Actual Valuation is Sub-Additive

The second class of scenarios of potential concern from assuming additive valuations of incentives is when the bidder actually holds a sub-additive valuation for a combination of NMIs (the NMIs are partial or complete substitutes for one another). In contrast to the case of supra-additive valuations described above, in this case the bidder would be assumed to hold a larger surplus for the combination of incentives than is actually the case, and may potentially be offered retention based upon an incentive

package that is insufficient to motivate him or her to retain. In this case, assuming the retention of such a sailor could cause the Navy to retain fewer sailors than expected and fall short of its retention goal.

Scenarios four through nine in Table 6 below illustrate cases in which a bidder has sub-additive valuations for two non-monetary incentives (labeled A and B) and yet it is assumed that the valuations are additive.

Scenarios 4, 6, 7, and 9 in Table 6 demonstrate instances in which no problem occurs from assuming additive valuation when actual valuation is sub-additive. In each of these scenarios, retention is offered to those willing to retain and retention is not offered to those who are unwilling to retain.

Scenario 5 demonstrates a situation in which the bidder is potentially willing to retain, but would require selling back either NMI A or NMI B to do so. Since the NMI's in the sub-additive "error" are substitutes, selling back to the Navy either of the NMIs would result in returning to the bidder some of their surplus that was lost under the additive assumption, and therefore push their cost to retain below the cutoff, and result in retaining the bidder, if he were allowed to sell back an NMI.

Scenario 8 is the only truly problematic scenario from Table 6, if we assume additivity in the presence of actual sub-additivity. In this situation, the assumed cost to retain is below the retention cost cut-off, and therefore the bidder is offered retention under the additive assumption. Given that the individual has sub-additive valuation for NMIs A and B, his actual cost to retain is driven above the cut-off. The result is that the bidder is offered retention, but the value of the package offered is not sufficient to entice the bidder to retain at this level.

Table 6. Illustration of problem scenarios and non-problem scenarios when assuming additive valuations.

Scenario	Min Cash to Retain	Value for NMI A	Value for NMI B	Value for both NMIs	Cost per NMI	Assumed Cost to Retain	Actual Cost to Retain	Cutoff Cost to Retain	Cash Incentive	Offered Retention?	Willing to Retain?	Problem?
1	40	10	10	30	8	36	26	40	24	Yes	Yes	No
2	40	10	10	30	8	36	26	30	14	No	Yes	Yes - Retainable @lower cost
3	40	10	10	30	8	36	26	20	4	No	No	No
4	40	10	10	17	8	36	39	44	28	Yes	Yes	No
5	40	10	10	17	8	36	39	38	22	Yes	No	No - Retainable with 1 NMI
6	40	10	10	17	8	36	39	32	16	No	No	No
7	40	10	10	17	6	32	35	38	26	Yes	Yes	No
8	40	10	10	17	6	32	35	34	22	Yes	No	Yes - Can't retain at cutoff cost
9	40	10	10	17	6	32	35	30	18	No	No	No

C. THE FREQUENCY OF ERROR WHEN ASSUMING ADDITIVE VALUATIONS

The previous section demonstrated how the presence of supra-additive or sub-additive valuations could potentially complicate the implementation of the CRAM if additive valuations are assumed. The question remains, however, as to how frequently such "errors" would occur in reality.

How frequently do supra-additive valuations actually occur? How frequently are such supra-additive valuations innocuous, such as in scenarios 1 and 3 from Table 6 above, and how frequently do they create the problem illustrated in scenario 2 above? Similarly, how frequently do sub-additive valuations actually occur? How frequently are such sub-additive valuations innocuous, such as in scenarios 4, 6, 7 and 9 from Table 6 above, and how frequently do they create the problem illustrated in scenario 8 above?

To address these questions, this research used a Monte Carlo simulation (using Crystal Ball simulation software) to model CRAM outcomes. The simulation was run for the enlisted survey data, but only included those NMIs for which respondents provided

their values for individual and all possible combinations of incentives (homeport, geographic stability for two tours and compressed work week; homeport, lump sum SRB, and telecommuting). The Monte Carlo simulation selected different NMI costs and we tracked two sets of CRAM results; assuming additive preferences and using the respondents' actual preferences. The range of error (instances in which the supra and sub-additive errors affected the final mix of sailors retained) was recorded based on 10,000 trials for the simulation results. The model was run for different retention levels (25%, 50%, and 75%) and the two different NMI cost distributions discussed above in the Enlisted Retention Study methodology (the all positive range of NMI values, VP(AP), and the upper half of the positive range for NMI values, VP(HP)). For reference the NMI cost ranges in the enlisted survey is provided in Table 7 below.

Table 7. Costs Estimations

	VP(AP) Lower bound Cost	VP(HP) Lower Bound Cost	Maximum Cost
Homeport	$1	$10,000	$50,000
Geographic Stability (2 tours)	$7	$5,539	$50,000
Compressed Work Week	$1	$5,000	$41,026
Telecommuting	$13	$7,750	$70,000
Lump Sum SRB	$3	$5,000	$90,000

For reporting purposes, I have assumed, as did Zimmerman (2008), that the NMI costs are more accurately depicted using the higher of the NMI costs assumptions (VP(HP)); the lower half of the value distributions would appear to represent unrealistically low costs for most of the associated NMIs. Further research is needed to more accurately estimate the NMI costs. The simulation results presented here are the average for the different NMI combinations and retention levels examined under the "higher NMI cost" assumption.

1. Supra-additive Error

The incidence of supra-additive error, based on our 10,000 trials, averaged less than 1% and the cost implications were limited. In these simulations, higher retention

and NMI cost levels decreased the margin of error. Given that this type of error has a minimal impact for implementing CRAM, we will not further discuss these findings.

2. Sub-additive Error

As previously discussed, the rate of sub-additive error could potentially be a cause for alarm, as this is the type of error which could potentially cause personnel planners to undershoot retention efforts utilizing CRAM. Fortunately, the rate of sub-additive error was less than 3% under the VP(HP) cost assumption using CRAM and this particular data set.

For accuracy and completeness, Table 8 below summarizes the average sub-additive error rates from each set of simulations conducted, both "low cost" and "high cost." Simulation outputs for all retention levels under high positive costs are included in Appendix A.

Table 8. Frequency of Sub-Additive Error in Simulations Assuming Additive Valuations

VP(AP) Cost Simulations					**VP(HP) Cost Simulations**			
	Min	Max	Mean			Min	Max	Mean
25 % Ret	3.3-4.6	24.5-25.7	12.9-16.3		25% Ret	0	6.6-7.3	1.9-2.48
50% Ret	1.99-4.98	8.97-14.95	4.65-9.05		50% Ret	0	4-4.7	0.78-0.96
75% Ret	0.66-1.77	4.87-5.75	2.6-3.8		75% Ret	0	2.4-3.98	0.49-1.03

In Table 8 above the labels min, max, and mean represent the percentage of time that Crystal Ball simulation returned a value that resulted in sub-additive error, based on the two developed cost estimations. As previously indicated, the higher cost estimation VP(HP) was the only result reported. The maximum error rate returned from Crystal Ball simulation was 7.3%, and the average error rate returned was 2.48%.

The results of this model indicate that less than 3% of the time there is difficulty associated with the making a sub-additive error, compared to the "full" model motivated by Zimmerman (2008). Overall, implementation of this model based upon additive assumptions offers a tremendous advantage in implementation, with limited consequences.

D. CRAM VARIATION I: BIDDER IDENTIFICATION OF SUPRA-ADDITIVE OR SUB-ADDITIVE COMBINATIONS

The previous section demonstrated that a simplified variation of the CRAM, in which bidders only submit valuations for NMIs on a "stand-alone" basis, could be implemented with very low frequency of error. Nonetheless, there are additional variations of the CRAM mechanism which further reduce (or even eliminate) such errors without requiring the complexity of the "full information" CRAM, in which bidder submit valuations for all possible combinations of NMIs.

For example, the survey data referenced in this thesis indicates that, while sub-additive and (to a lesser degree) supra-additive valuations do indeed exist, it is often the case that (1) the value of certain or even many NMI combinations do exhibit perfect additivity or approximate ("close enough") additivity for some individuals, and/or (2) much or all of the sub- or supra-additivity in valuations is captured in combinations of two NMIs, limiting the value or necessity of inquiring about combinations of three or more NMIS.

Hence, another variation of CRAM that could potentially further address sub- and supra-additive preferences would assume additive values as a default, but allow individual bidders to identify cases where they value combinations of incentives as either sub-additive or supra-additive. This implementation could reduce the information requirements of additive valuations, while increasing accuracy within the model by allowing individuals to make it expressly clear which incentives are significant substitutes or complements.

E. CRAM VARIATION II: MENU OR CAFETERIA CRAM

A particularly appealing variation of the CRAM is the so-called "menu" or "cafeteria" variation. The menu CRAM approach incorporates and compensates for sub- or supra-additive preferences 100% of the time, while also minimizing the bid submission burden placed on service-members.

The menu CRAM method provides the opportunity for service members to individually choose which incentives they desire from a given set of NMI offerings. Menu CRAM is implemented as follows:

- Service members are provided a list or "menu" of available non-monetary incentives along with their associated costs
- Service members identify which NMIs they value more than cost
  - *Each NMI is selected with full information about the other NMIs chosen, so service members themselves must consider supra- or sub-additivity*
- Service members also submit a bid indicating the minimum cash bonus they would need to retain
  - *The cash bid assumes that they would receive all NMIs chosen from menu if retained*
- The cost of each retention "package" is calculated and service members with lowest cost packages are retained
  - *Cost = cash bid + cost of all NMIs chosen from the menu*

The menu CRAM fully incorporates the non-additive preferences of valuation of non-monetary incentives. As identified above, the cost of each package is determined by identification of a cash bid plus the cost of any incentives the bidder chooses as part of the retention package. Each bidder knows the cost of each incentive, and must therefore choose the combination of NMIs that maximizes value for the individual. In this regard, the individual must make the determination of substitution or complementary affects among the NMIs chosen.

Since the bidder has knowledge of NMI costs, and will receive all chosen NMIs if they are retained, the optimal strategy is to submit a cash bid that is equal to their minimum value for willingness to retain, minus the cost of the NMIs they have chosen. If their total package bid is equal to the minimum cost to retain the first excluded sailor, they will be retained.

To more fully explore the subtle differences between menus CRAM and CRAM under limited information conditions, scenarios 2, 5, and 8 from Table 6 are addressed under menu CRAM conditions.

Scenario 2: The bidder values NMIs as supra-additive at 30, and therefore would require a cash bid of 10 (minimum package value to retain (40) – value of NMIs (30)).

The cost of the NMIs is 16, so the total package cost 26 (cash bid (10) + cost of NMIs (16)) which is below the cutoff of 30, and the bidder is retained. In this case, the bidder explicitly indicated supra-additive valuation for the combination of incentive A and B.

Scenario 5: The bidder values NMIs as sub-additive at 17, and therefore would require a cash bid of 23 to reach his minimum package total to retain. With a cash bid of 23, the total cost is 39, which is above the cutoff of 38, and therefore the bidder would not be offered retention.

In this scenario, if the bidder were to choose only one NMI at a value of 10, then the cash bid would be 30 and the total cost would be 38, and therefore the bidder would be offered retention. Again, the bidder is required to address sub- and supra-additivity related to the NMIs.

Scenario 8: In scenario 8, again the bidder values NMIs sub-additively at 17, which results in cash bid of 23. The total package cost is 35, above the cutoff of 34. The bidder is not offered retention.

Under an assumption of additive valuations, the bidders in scenarios 2, 5, and 8 were each offered retention (or not) in error. Under the menu CRAM the responsibility for determination of sub- and supra-additivity of incentives was placed on the bidder and resulted in more accurate retention offerings.

The drawback to the menu type CRAM is that it requires a reasonable *ex- ante* estimate of costs. To complicate matters, NMI costs likely vary with the level of utilization. As utilization increases, the marginal cost of providing many incentives increases. Proper insight to utilization, and therefore costs, is required to use a menu type CRAM.

One approach to address demand uncertainty would be to conservatively state relatively high NMI costs when CRAM is first introduced; this would guard against unexpectedly high NMI demand. As NMI demand data accumulates over time, the cost estimates could be refined to better represent the true NMI costs.

F. CONCLUSION

This chapter has explored the complexity of the valuation elicitation problem, including “perfect” information versus the more limited information necessary to use

CRAM to set retention incentive packages. This chapter explored the two types of errors which we expect to occur as a result of assuming additive valuations: (1) failing to retain sailors with *supra-additive* preferences who could be retained below the "cutoff" cost; and expecting to retain sailors with *sub-additive* preferences who ultimately do not want to be retained, given the combination of monetary and non-monetary incentives offered to them by the mechanism. After 10,000 trials of a Monte Carlo simulation model, the available data has shown that assuming additive values for non-monetary incentives does not produce significant differences compared to a "full information" model.

Finally, additional simplified CRAM variations which incorporate non-additive valuations were discussed. The results discussed here show there are multiple approaches available to implement a combinatorial retention auction mechanism in a manner which is both practical and accurate.

VII. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This thesis has sought to advance previous research by evaluating information elicitation factors related to utilizing non-monetary incentives, particularly as part of a Combinatorial Retention Auction Mechanism. Given the approach taken by this thesis, variability in individual preferences and valuation of non-monetary incentives was an underlying and pervasive theme.

Related specifically to variability, this research concluded there are four ways in which variability relates to non-monetary incentives:

- Variability Across Non-Monetary Incentives
- Variability Across Populations
- Variability Within a Given Population
- Variability Within Individual Preferences Over Incentive Combinations

These sources of variability, while potentially problematic, actually serve as the compelling aspect of use of non-monetary incentives. Accommodating for this variability via an appropriate methodology is critical, but if an appropriate model is chosen, implementation is easily accomplished and the opportunity to provide individualized incentive packages is maintained.

The model in this research assumed additive valuations of the incentives within the CRAM model. The simulation results showed that assuming additive valuations did not significantly affect outcomes when compared to the "full information" model. Due to the greater ease of implementation, a limited model which assumes additive valuation should be considered as an option for implementing the CRAM.

Ultimately, variability in non-monetary incentive valuation is pervasive and important in consideration of NMI offerings. While variability influences the potential to implement non-monetary incentives as a force-shaping tool, variability does not obstruct its use.

Non-monetary incentives should be further considered as a valuable retention tool, but:

- Must be careful which NMIs are provided
- Must be careful to whom NMIs are offered
- Must be careful in how NMI programs are implemented

The Combinatorial Retention Auction Mechanism is able to fully accommodate for variability in the valuation of non-monetary incentives. Considerations to implementation via the CRAM include:

- A "full information" approach requires eliciting data on 2^n preferences, and therefore could be data intensive, depending on the number of incentives offered
- Simpler variations of the CRAM (additive or menu-style) provide practical solutions to implementation with limited adverse consequences.
- The additive valuation assumption with limited information will provide an adequate compromise

The menu-style CRAM can accommodate all types of variability, but requires estimating ex ante cost. NMI costs are a significant factor in this thesis that can have a tremendous impact on the benefits of NMIs. Not only are costs largely unknown, they will likely vary with changes in retention level. To fully and accurately predict the benefit of any of these models, an accurate estimation of costs should be developed.

B. RECOMMENDATIONS

1. Investigate further the supra or sub-additive nature of NMI valuations

   This research was motivated based on a limited sample size. The combinatorial aspects, although significant, should be further explored, with particular attention to differences between "populations" within the Navy.

2. Estimate cost of NMIs at various levels of provision or use

   The level of use of non-monetary incentives will likely have a significant impact of the costs associated with providing incentives. Broad investigation of the "top

10” non-monetary incentives that sailors value will provide insight to the nature of incentive valuation, as well as which incentives should be included as part of a non-monetary incentive program.

3. Conduct simulation experiments to test and refine menu CRAM approach Motivation of the CRAM with improved cost information will provide a better understanding of the potential costs savings the Navy might enjoy. Further, this information will provide better prediction of the type of retention expectations that should be possible with the CRAM.

4. Evaluate CRAM (menu or otherwise) via small "test market" implementation for some particular rating or cohort.

   A certain level of pain and resistance is expected from implementing the CRAM. Any new process or policy will likely be met with resistance and apprehension. The best opportunity to gain support and understanding of a non-monetary incentive program is with buy-in from sailors. Vital lessons will be learned from early implementation efforts, and a small cohort size will minimize implementation problems.

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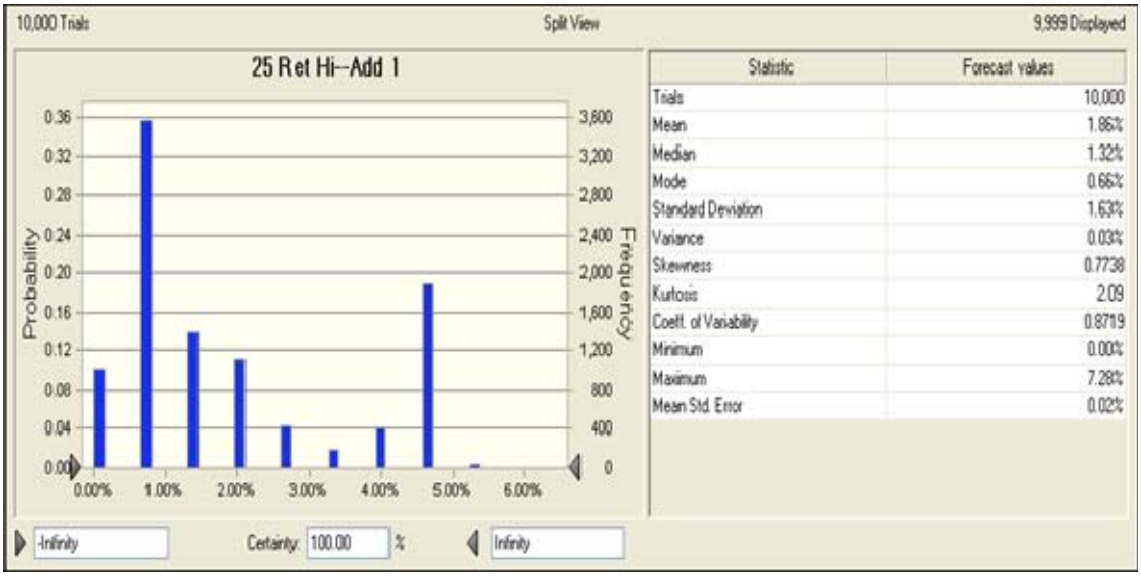
APPENDIX

A. SIMULATION RESULTS

The following charts depict the incidence of sub-additive errors for 10,000 Monte Carlo simulation trials within the "additive" model assumed for this research. The title of each slide designates the retention level (as a percentage), high (VP(HP)) cost basis, and combination of incentives represented by the chart. For example, the first chart represents 25% retention rate, high cost estimate VP(HP), and incentive combination Add 1 (homeport choice, Geographic stability 2 tours, and compressed work week). The Add 2 combination includes home port choice, lump sum SRB, and telecommuting




10,000 Trials
Split View
9,997 Displayed
25 Ret Hi--Add 2
Probability
Frequency
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0.15
0.12
0.09
0.06
0.03
0.00
1,800
1,500
1,200
900
600
300
0
0.00%
1.00%
2.00%
3.00%
4.00%
5.00%
6.00%
-Infinity
Certainty: 100.00 %
Infinity
Statistic
Forecast values
Trials 10,000
Mean 2.47%
Median 2.65%
Mode 1.32%
Standard Deviation 1.31%
Variance 0.02%
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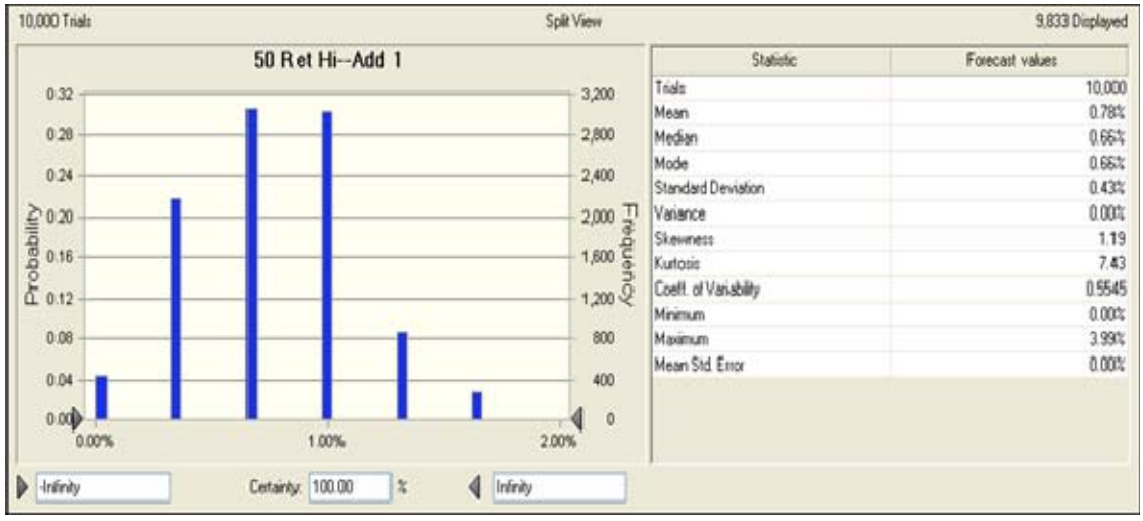
Kurtosis 2.53
Coeff. of Variability 0.5287
Minimum 0.00%
Maximum 6.62%
Mean Std. Error 0.01%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9,833 Displayed
50 Ret Hi--Add 1
Probability
Frequency
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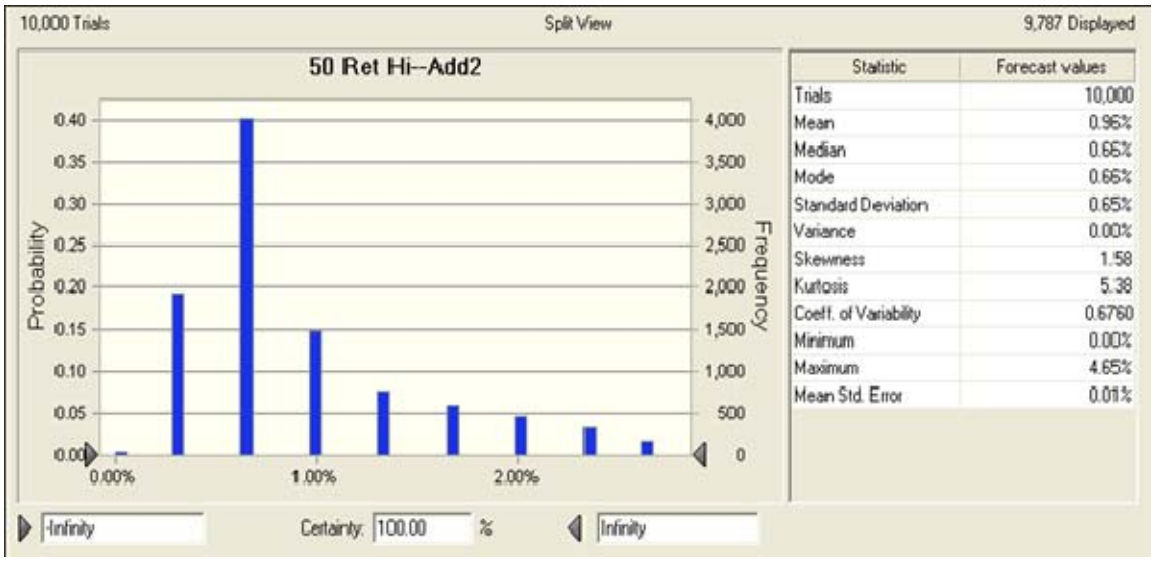
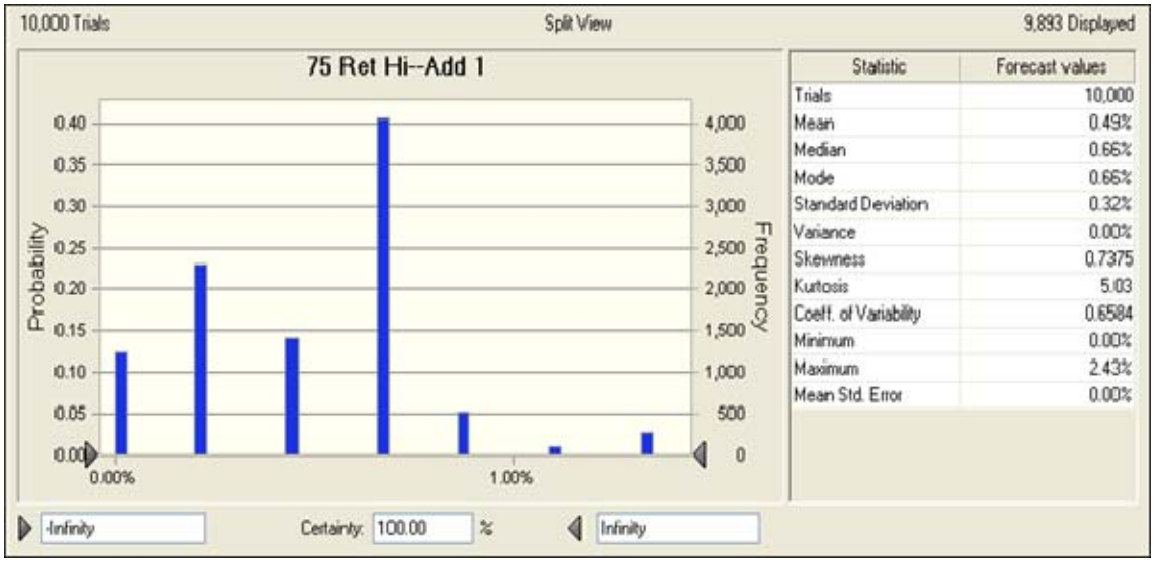
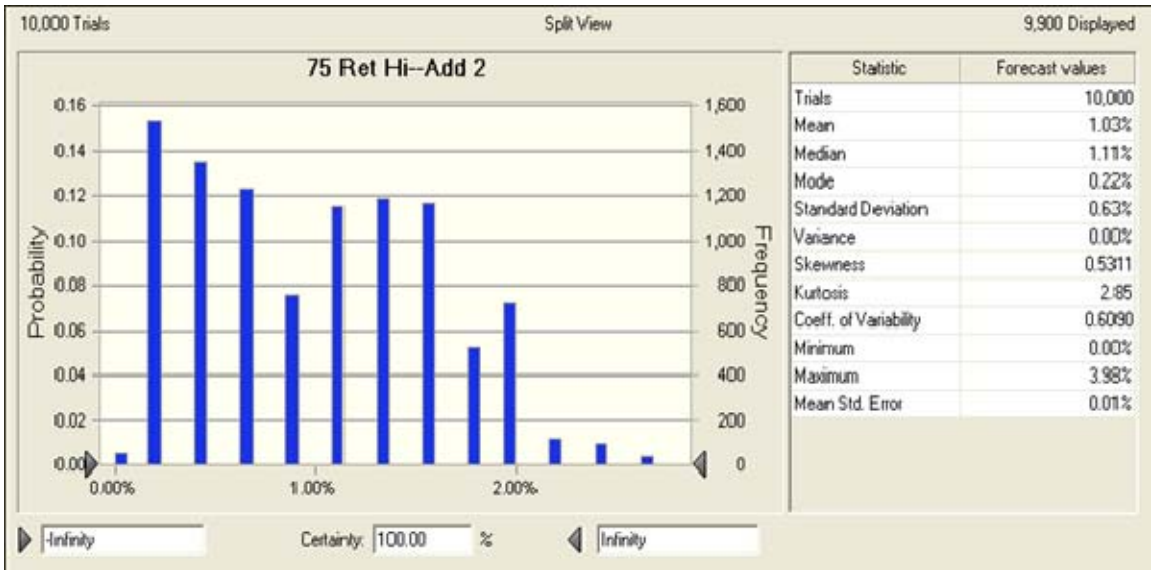
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00
3,200
2,800
2,400
2,000
1,600
1,200
800
400
0
0.00%
1.00%
2.00%
-Infinity
Certainty: 100.00 %
Infinity
Statistic
Forecast values
Trials 10,000
Mean 0.78%
Median 0.66%
Mode 0.66%
Standard Deviation 0.43%
Variance 0.00%
Skewness 1.19
Kurtosis 7.43
Coeff. of Variability 0.5545
Minimum 0.00%
Maximum 3.99%
Mean Std. Error 0.00%


10,000 Trials
Split View
9,787 Displayed
50 Ret Hi--Add2
Probability
Frequency
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.00%
1.00%
2.00%
-Infinity
Certainty: 100.00 %
Infinity
Statistic
Forecast values
Trials 10,000
Mean 0.96%
Median 0.65%
Mode 0.65%
Standard Deviation 0.65%
Variance 0.00%
Skewness 1.58
Kurtosis 5.38
Coeff. of Variability 0.6760
Minimum 0.00%
Maximum 4.65%
Mean Std. Error 0.01%


10,000 Trials
Split View
9,893 Displayed
75 Ret Hi--Add 1
Probability
Frequency
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.00%
1.00%
-Infinity
Certainty: 100.00 %
Infinity
Statistic
Forecast values
Trials 10,000
Mean 0.49%
Median 0.66%
Mode 0.66%
Standard Deviation 0.32%
Variance 0.00%
Skewness 0.7375
Kurtosis 5.03
Coeff. of Variability 0.6584
Minimum 0.00%
Maximum 2.43%
Mean Std. Error 0.00%


10,000 Trials
Split View
9,900 Displayed
75 Ret Hi--Add 2
Probability
Frequency
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
1,600
1,400
1,200
1,000
800
600
400
200
0
0.00%
1.00%
2.00%
-Infinity
Certainty: 100.00 %
Infinity
Statistic
Forecast values
Trials 10,000
Mean 1.03%
Median 1.11%
Mode 0.22%
Standard Deviation 0.63%
Variance 0.00%
Skewness 0.5311
Kurtosis 2.85
Coeff. of Variability 0.6090
Minimum 0.00%
Maximum 3.98%
Mean Std. Error 0.01%

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