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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

IMPROVING NAVY RECRUITING WITH THE NEW PLANNED RESOURCE OPTIMIZATION MODEL WITH EXPERIMENTAL DESIGN (PROM-WED)

by

Allison R. Hogarth

March 2017

Thesis Advisor: Co-Advisor: Second Reader: Thomas Lucas Connor McLemore Paul Sanchez

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The Navy spends over \$300 million per year to recruit approximately 35,000 new active duty enlisted Sailors. The Navy has historically used a non-linear optimization model, the Planned Resource Optimization (PRO) model, to help inform decisions on the allocation of those recruiting resources. Input variables to the PRO model include economic influences and policy factors. The result is a recommended allocation of resources for advertisements, recruiters, enlistment bonuses, and education incentives. The PRO model's primary limitations are (1) potential deviations of input variables are not taken into consideration, and (2) extensive experimentation is not feasible. Realistically, input variables to the PRO model fluctuate, are unpredictable, and can interact with other variables to influence the recruiting environment and affect the optimal allocation of recruiting resources. This paper describes the "Planned Resource Optimization Model with Experimental Design" (PROM-WED), a tool that alleviates the limitations and enhances the analytic utility of the legacy PRO model. PROM-WED embeds the legacy PRO model within a data farming environment. PROM-WED's graphical user interface and decision support capability provide decision makers with robust insights into variable interactions and uncertainties to better inform their recruiting resourcing decisions.							
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IMPROVING NAVY RECRUITING WITH THE NEW PLANNED RESOURCE OPTIMIZATION MODEL WITH EXPERIMENTAL DESIGN (PROM-WED)

Allison R. Hogarth Lieutenant, United States Navy B.S., The George Washington University, 2012

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH

from the

NAVAL POSTGRADUATE SCHOOL March 2017

Approved by: Thomas Lucas Thesis Advisor

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ABSTRACT

The Navy spends over \$300 million per year to recruit approximately 35,000 new active duty enlisted Sailors. The Navy has historically used a nonlinear optimization model, the Planned Resource Optimization (PRO) model, to help inform decisions on the allocation of those recruiting resources. Input variables to the PRO model include economic influences and policy factors. The result is a recommended allocation of resources for advertisements, recruiters, enlistment bonuses, and education incentives. The PRO model's primary limitations are (1) potential deviations of input variables are not taken into consideration, and (2) extensive experimentation is not feasible. Realistically, input variables to the PRO model fluctuate, are unpredictable, and can interact with other variables to influence the recruiting environment and affect the optimal allocation of recruiting resources. This paper describes the "Planned Resource" Optimization Model with Experimental Design" (PROM-WED), a tool that alleviates the limitations and enhances the analytic utility of the legacy PRO model. PROM-WED embeds the legacy PRO model within a data farming environment. PROM-WED's graphical user interface and decision support capability provide decision makers with robust insights into variable interactions and uncertainties to better inform their recruiting resourcing decisions.

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LIST OF ACRONYMS AND ABBREVIATIONS

AFQT	Armed Forces Qualification Test
ASVAB	Armed Services Vocational Aptitude Battery
AVF	all-volunteer force
CPT	cost-performance tradeoff
DOD	Department of Defense
DOE	design of experiments
EB	enlistment bonus
FY	fiscal year
GAO	Government Accountability Office
GED	general educational development
GUI	graphical user interface
HumRRO	Human Resources Research Organization
JPM	Job Performance Measurement/Enlistment Standards
LRP	loan repayment program
MEU	Marine Expeditionary Unit
MIP	mixed integer program
MPT&E	Manpower, Personnel, Training and Education
N1	Deputy Chief of Naval Operations for Manpower, Personnel, Training and Education
NCF	Navy college fund
NCO	new contract objective
NEC	Navy enlisted classification
NF	nuclear field
NOLH	nearly orthogonal Latin hypercube
NOS	Navy occupational specialties
NPS	Naval Postgraduate School
NRC	Navy Recruiting Command
OSAM	Officer Strategic Analysis Model
OSD	Office of the Secretary of Defense
PC	personal computer

POM	program objective memorandum
POR	program of record
PPBE	Planning, Programming, Budget and Execution
PRO	Planned Resource Optimization
PROM-WED	Planned Resource Optimization with Experimental Design
QMA	qualified military available
SEAL	sea, air and land
SEED	Simulation Experiments & Efficient Designs
STORM	Synthetic Theater Operations Research Model
TSC	Test Score Category
UE	unemployment rate
VBA	Visual Basic for Applications

EXECUTIVE SUMMARY

The mission of the United States Navy is "to maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas" (United States Navy, n.d.-b). Congress authorizes the Navy to maintain a force-strength of over 300,000 active duty personnel to execute this mission (Government Accountability Office, 2016, p. 5). The Navy spends over \$300 million to recruit approximately 35,000 new active duty enlisted Sailors each year to sustain its manning strength (Department of the Navy, 2015, p. 7). Under the Deputy Chief of Naval Operations for Manpower, Personnel, Training and Education (N1/MPT&E), analysts use mathematical models to support decision makers on personnel and budget related resourcing issues (United States Navy, n.d.-a). One model that N1 has historically used to inform recruiting resourcing decisions is the Planned Resource Optimization (PRO) model.

The PRO model is a deterministic non-linear optimization model that provides users with a recommended set of resources to minimize the cost of Navy recruiting (Green & Mavor, 1994). The PRO model optimizes resources allocated to advertisements, enlistment bonuses, education incentives, and recruiters. Input variables to the model include economic influences such as unemployment rate and policy factors such as percentage of high quality recruits (Navy Recruiting Command, 2007). Limitations of the PRO model are (1) potential deviations of input variables are not taken into consideration, and (2) extensive experimentation is not feasible. Realistically, the input variables to the PRO model fluctuate, are unpredictable, and can interact with other variables to influence the recruiting environment and affect the optimal allocation of recruiting resources.

To alleviate the limitations and enhance the analytic utility of the legacy PRO model, we developed the "Planned Resource Optimization Model with Experimental Design" (PROM-WED). PROM-WED embeds the legacy PRO model within a data farming environment. The foundation of PROM-WED's data farming wrapper is the nearly orthogonal Latin hypercube (NOLH). The NOLH design of experiments (DOE) builds experimental designs that efficiently and effectively explore the solution space (Cioppa & Lucas, 2007). This good spacefilling capability means that uncertainties and fluctuations in input variables along with multivariable interactions can be adequately investigated (Sanchez & Wan, 2015).

The 33 and 129 design point NOLH designs were used to construct PROM-WED's data farming wrapper. The 33-point NOLH DOE tests each variable at 33 levels and grows data for 33 legacy PRO model runs, whereas the 129-point NOLH DOE tests each variable at 129 levels and grows data for 129 legacy PRO model runs. PROM-WED's graphical user interface (GUI) allows users to easily input a range of values for each input variable into the NOLH DOE worksheet, without need for knowledge or familiarity with data farming or DOE techniques (Sanchez, 2011).

A completed PROM-WED excursion grows a data set for either 33 or 129 data points. Automatically generated sensitivity analysis provides users with a basic risk assessment picture focused on the decision variables using the data grown by PROM-WED. Further insights into variable interactions and effects of input variables can be easily explored using available data analysis software. PROM-WED transforms the legacy PRO model into a resource that N1 can use to gain robust insights into the optimal allocation of recruiting resources.

A scenario of interest to N1 was run and analyzed using PROM-WED. Insights gained include:

- 1. To optimize the allocation of recruiting resources in fiscal year 2020, it is recommended that less funds be allocated to recruiters and more funds be allocated to enlistment bonuses and advertisements.
- 2. Advertising is the most influential decision variable. Over 80 percent of the total cost of recruiting variance is explained by changes in the recommended allocation of resources to advertising.

3. Once relative pay exceeds approximately 1.00, changes in the new accession mission have little to no effect on the recommended amount of resources allocated to advertising.

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I. INTRODUCTION

The mission of the United States Navy is "to maintain, train and equip combat-ready Naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas" (United States Navy, n.d.-b). Under Title 10 of the United States Code, Congress authorizes the Navy to maintain a force-strength of over 300,000 active duty personnel to execute this mission (Government Accountability Office [GAO], 2016, p. 5). Each year, the Navy recruits approximately 35,000 new active duty enlisted Sailors to sustain this manning strength (Department of the Navy, 2015, p. 7). The Deputy Chief of Naval Operations for Manpower, Personnel, Training and Education (MPT&E/N1) is delegated with the responsibility over all Navy manpower readiness matters, to include recruiting (United States Navy, n.d.-a).

Analysts at N1 use mathematical models and simulations to support decision makers in the MPT&E domain during the Planning, Programming, Budget and Execution (PPBE) process. The PPBE process is the Department of Defense's (DOD) "primary resource management system... for all appropriated funding" (Tomasini, n.d.). The DOD's strategy, force structure, and allocation of resources are all delineated within the annual PPBE process (Tomasini, n.d.). Each year during the programming phase, N1 submits Program Objective Memorandum (POM) inputs, recommending how funds should be allocated within the Navy's MPT&E domain (Defense Acquisition University [DAU], 2013, p. 4).

N1 has historically used the Planned Resource Optimization (PRO) model to inform decisions regarding the allocation of recruiting resources and estimate total recruiting costs. The PRO model is a deterministic, non-linear optimization model that provides users with a recommended set of resources that minimizes the cost of recruiting in order to achieve a given recruiting mission. The PRO model can also be used to estimate recruiting capacity for a given level of resources. The PRO model is built in Microsoft Excel using both worksheet functions and Visual Basic for Applications (VBA) code. The PRO model's primary function is to provide a broad, estimated budget picture of Navy recruiting resource allocation in support of the POM. The PRO model is also used to answer questions such as, "what is the least expensive way to meet a recruiting mission?" and "how much money do we need to allocate for advertising to meet a given accession mission?" (Hogarth, Lucas, & McLemore, 2016, p. 3576)

A. PROBLEM STATEMENT

Recruiting a high quality all-volunteer force (AVF) is expensive. The Navy requires a growing number of high quality recruits to meet the needs of its technologically advanced fleet. In a perfect world, N1 would be given a blank check to cover the cost of recruiting a 100 percent high quality force. However, in reality, N1 faces a fiscally constrained environment.

The PRO model is a deterministic, non-linear optimization model that provides users with a recommended set of resources that attempts to minimize the cost of recruiting (Green & Mavor, 1994). Analysts at N1 use the PRO model to optimize resources allocated to advertisements, enlistment bonuses, education incentives, and recruiters. Input variables include economic influences such as unemployment rate, and policy factors such as target percentage of high quality recruits (Navy Recruiting Command, 2007). The PRO model's primary limitations are (1) deviations of input variables are not taken into consideration, and (2) extensive experimentation capability is not available. Realistically, the input variables to the PRO model fluctuate, are unpredictable, and can interact with other variables to influence the recruiting environment and affect the optimal allocation of recruiting resources.

B. THESIS PURPOSE

The objective of this research is to develop a tool that transforms the PRO model into a tool that provides N1 analysts with a robust decision support capability for recruiting resourcing decisions. In this research, the author wrapped

a design of experiments (DOE) capability around the legacy PRO model. We call the enhanced tool the Planned Resource Optimization Model with Experimental Design (PROM-WED).

The data farming wrapper in PROM-WED provides legacy PRO model users with the ability to input a range of possible values for input and decision variables. The legacy PRO model is run over each scenario that is formulated by the DOE tool. Instead of a single, discrete solution found by the legacy PRO model, PROM-WED grows data that gives robust insight into cause and effect relationships amongst the variables.

C. RESEARCH QUESTIONS

In order to best provide N1 analysts with a tool that improves their decision support analysis for recruiting budget estimates and resource allocation, this research is guided by the following questions:

- 1. How can design of experiment techniques better inform decision maker's determination of the optimal and robust combination of recruiting resources?
- 2. How can efficient design of experiment techniques be incorporated around the PRO model for future, on-the-spot risk and sensitivity analysis?
- 3. Can an enhanced PRO model give decision-makers a robust solution for the optimal allocation of recruiting resources?

D. METHODOLOGY

PROM-WED's data farming wrapper uses the Nearly Orthogonal Latin Hypercube (NOLH) DOE worksheet tool developed by the Simulation Experiments & Efficient Designs (SEED) Center for Data Farming at the Naval Postgraduate School (NPS), see <u>https://harvest.nps.edu</u>. A new graphical user interface (GUI) allows the user to input a range of values for each input variable into the NOLH DOE worksheet. The NOLH DOE worksheet was embedded into the PRO model. The user has the option to run an excursion using a 33-point design or a 129-point design. PROM-WED generates a robust recommended allocation of recruiting resources. Basic sensitivity analysis provides the user with a risk assessment picture, and further analysis can be completed using any data analysis software package, such as JMP. Scenarios of interest to N1 are run and analyzed.

E. BENEFITS OF RESEARCH

The ability to quickly explore scenarios with a deterministic optimization model using efficient DOE techniques provides N1 with richer insights into combinations of resources that can be utilized to achieve a given active enlisted recruiting mission. Instead of a discrete expected value, the implementation of efficient DOE techniques provides decision-makers with a "robust [foundation to make] decisions or policies" (Sanchez, Sanchez, & Wan, 2014, p. 1). DOE methods will also provide improved insight into tradeoff relationships between input parameters and the output results (Vieira, Sanchez, Kienitz, & Belderrain, 2013, p. 264). N1 will also benefit from this study by gaining a tool that provides on-the-spot sensitivity analysis using sophisticated DOE techniques.

F. ORGANIZATION OF THESIS

This thesis is comprised of five chapters. Chapter I focuses on the motivation of the thesis and explains how the research questions are addressed. Chapter II discusses the history and composition of the PRO model and considers other research that has been done on military recruiting resource allocation and the implementation of data farming on simulation models. Chapter III addresses the methodology used to build PROM-WED, including a review of DOE techniques, and the components of PROM-WED. Chapter IV introduces scenarios of interest to N1, and the remainder of the chapter provides an analysis of the data generated for these scenarios using PROM-WED. Last, Chapter V provides concluding remarks, and recommendations for further work.

4

II. BACKGROUND

In this chapter, research on military recruiting resource allocation is presented, followed by a conceptual overview of the PRO model.

A. LITERATURE REVIEW

All military branches face the challenge of determining the best way to allocate recruiting resources. PRO is a model that the Navy has historically used to help decision makers gain insight to answer this question.

1. Recruiting Resource Allocation Models

Following the United States withdrawal from the Vietnam War in 1973, Congress terminated conscription, and the military transitioned to an All-Volunteer Force (AVF) (Morey & McCann, 1980, p. 1198). Critics of an AVF were concerned that it would result in weakened national security due to low quality recruits and insufficient accession numbers. In contrast to a military manned by conscripts, an AVF forced each service to expend more effort "to meet the various quantity and quality goals" for recruiting new enlistees (Morey & McCann, 1980, p. 1198). Various modeling efforts were made to gain insight into how to best allocate recruiting resources to meet the service's set recruiting goals.

In 1978, Chappell and Peel developed static and dynamic optimization models to determine the optimal allocation of advertising resources to achieve military recruiting goals. The dynamic model they developed introduced economic factors such as labor supply and incorporated current and past recruiting data to determine an optimal allocation of advertising resources (Chappell & Peel, 1978, p. 910).

In 1980, Morey and McCann developed a model to determine the optimal allocation of recruiting resources by inputting econometric data of a given region and descriptive data that reflects its demographic population. The model was conducive to "perform[ing] sensitivity analyses related to the impacts" of various

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economic and demographic changes. Their model identified the percentage of recruits who graduated from high school as the indicator for recruit quality (Morey & McCann, 1980, p. 1204).

2. Cost-Performance Tradeoff Model

AVF concerns peaked in 1980, particularly in regards to how the military gauged recruit quality (Green & Mavor, 1994, p. 8). The DOD informed Congress that the Armed Services Vocational Aptitude Battery (ASVAB), the examination used to determine enlistment eligibility, was incorrectly scored between 1976 and 1980 (Green & Mavor, 1994, p. 2). This error resulted in hundreds of thousands of people entering military service who did not meet enlistment standards (Green & Mavor, 1994, p. 2).

Clinical psychologists advised that the recruits who did not meet minimum enlistment standards were classified as individuals who "generally need intense supervision and guidance, particularly under conditions of serious stress" (Laurence & Ramsberger, 1991, p. 8). These attributes are undesirable for military service.

In reaction to this mistake, Congress tasked the DOD "to link enlistment standards to job performance" (Green & Mavor, 1994, p. 2). This initiated the Joint-Service Job Performance Measurement/Enlistment Standards (JPM) Project. The first phase of the JPM project "concentrated on developing a variety of measures of job performance so that enlistment standards could be related to something close to actual performance on the job" (Green & Mavor, 1994, p. 7).

Following decades of research, phase one of the JPM project validated the ASVAB as "a reasonably valid predictor for performance in entry-level military jobs" (Green & Mavor, 1994, p. 10). High school graduation became an indicator of likelihood of first term enlistment completion. The military services now faced the challenge of determining "how much quality can we afford?" since "highquality personnel cost more to recruit, and the public purse is not bottomless" (Green & Mavor, 1994, p. 4,10-11). The goal of the second phase of the JPM project was to address this question. The cost-performance tradeoff (CPT) model was their solution (Green & Mavor, 1994, p. 11).

The CPT model is a tool that decision makers use to estimate the "probable effects on performance and/or costs of various scenarios" (Green & Mavor, 1994, p. 11). The CPT model is comprised of "four primary components: (1) the performance equations, (2) the recruiting cost function, (3) survival rates, and (4) training and compensation costs" (McCloy at al.,1992, p. iii). The PRO model is based upon the recruiting cost function, which is covered in the next section.

B. PLANNED RESOURCE OPTIMIZATION MODEL

The PRO model is a non-linear optimization model implemented in Microsoft Excel using both worksheet functions and VBA code. It evaluates user driven input variables over a recruiting cost function. The result is a recommended combination of recruiting resources to meet a given recruiting mission.

1. Components of the PRO Model

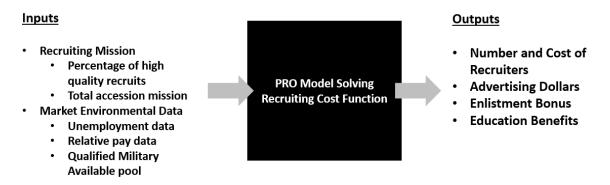
The PRO model uses the recruiting cost function from the CPT model to allocate recruiting resources while minimizing the cost of recruiting. A general review of the PRO model's conceptual framework and an overview of the workings of the PRO model follow.

a. Conceptual Framework

Input variables to the PRO model include decision variables, market factors, and policy factors that affect the cost and nature of recruiting. Users can change these inputs to test different recruiting scenarios. Figure 1 shows a conceptual representation of the PRO model.

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Figure 1. Conceptual Representation of the PRO Model



Adapted from Navy Recruiting Command (2007, p. 5).

A PRO model excursion produces a point solution that tells the user how many production recruiters should be in the field along with the allocation of funds towards enlistment bonuses, education incentives, and advertisements. An example output of a PRO model excursion is shown in Figure 2.

	Resource Run	2015	2016	2017	2018	2019	2020	2021
	NCO	35,025	36,425	36,800	35,800	35,225	34,650	34,650
	Capacity	N/A						
	Unemployment (%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Float	Total Recruiters	4,092	4,632	4,608	4,315	4,106	3,945	3,923
	Total Recruiter Cost (\$M)	\$335.138	\$383.495	\$387.265	\$368.083	\$355.535	\$347.480	\$351.645
Float	Advertising (SM)	\$86.203	\$105.531	\$105.352	\$97.179	\$91.278	\$87.362	\$87.981
Fixed	Enlistment Bonus (\$M)	\$40.971	\$36.580	\$41.340	\$40.650	\$42.230	\$42.060	\$42.810
Float	Education Incentives (\$M)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
	LRP (\$M)	\$7.440	\$11.220	\$11.280	\$11.380	\$11.430	\$11.460	\$11.670
	HSDG	95%	95%	95%	95%	95%	95%	95%
	TSC I-IIIA	70%	70%	70%	70%	70%	70%	70%
	Total Cost (\$M)	\$469.752	\$536.826	\$545.236	\$517.292	\$500.473	\$488.361	\$494.106

Figure 2. PRO Model Output

Program Objective Memorandum (POM) FY17 version of the PRO model.

The interpretation of the point solution for fiscal year (FY) 2015 in Figure 2 is: To meet an accession mission of 35,025 new Navy recruits with a fixed enlistment bonus budget of \$40,971,000, the Navy should allocate 4,092 Sailors to recruiting duty and \$86,203,000 to advertising.

b. The Recruiting Cost Function

The recruiting cost function is "the underpinning of the [PRO] model" (Navy Recruiting Command, 2007, p. 6). The black box shown previously in Figure 1 represents the recruiting cost function. Users cannot alter the recruiting cost function to include the elasticities or pre-set data that feed into it.

The recruiting cost function provides the "minimum cost budget" recommended to recruit "a specified number of individuals" while taking into consideration the conditions of the "recruiting market" (Green & Mavor, 1994, p. 126–127). Enlistment supply functions and a constrained minimization problem are both critical components of the recruiting cost function (Green & Mavor, 1994, p. 1994, p. 126–127).

The variables of interest that build the recruiting cost function include (Green & Mavor, 1994, p. 126–127; Katznelson, 2010, p. 4; Navy Recruiting Command, 2007, p. 8.):

H = High quality recruits

- $M = Medium \ quality \ recruits$
- L = Low quality recruits
- C^q = Number of contracts signed in a given year, where q = H, M, L
- $C_0^q = Constant (calculated using base year knowns), where q = H, M, L$
- $C_*^q = Minimum \ cost \ to \ contract \ given \ number \ of \ recruits, where \ q = H, M, L$
- $\lambda_q = Lagrangian multiplier, where q = H, M, L$
- $\alpha = Elasticity$ describing the relationship between the paramter and C^{H}
- R^q = Number of production recruiters to recruit a given quality, where q = H, M, L
- $AD = Advertising \ dollars \ spent \ in \ the \ model \ year \ (inflation adjusted \ to \ base \ year)$
- $B = Average \ enlistment \ bonus \ paid \ to \ q = H \ (model \ year)$
- E = Average education benefits paid to q = H (model year)
- v = Price index to deflate B and E into base year dollars
- F = Factors affecting the recruiting market (i.e., unemployment, relative pay)
- $T = Testing \ cost$
- 0 = Fixed costs of recruiting

The enlistment supply functions, shown in Figure 3, are separated into high, medium, and low quality categories of new accessions. These equations determine the expected number of recruits in each category that will be contracted per year (Green & Mavor, 1994, p. 126).

Figure 3. Enlistment Supply Functions

High Quality Contracts:

 $\ln(C^H) = \ln(C_o^H) + \alpha_R^H \ln(R^H) + \alpha_{AD} \ln(R^H) + \alpha_B ln\left(\frac{B}{v}\right) + \alpha_E ln\left(\frac{E}{v}\right) + \alpha_F \ln(F)$

Medium Quality Contracts: $\ln(C^M) = \ln(C_o^M) + \alpha_R^M \ln(R^M) + \alpha_F \ln(F)$

Low Quality Contracts: $\ln(C^L) = \ln(C_o^L) + \alpha_R^L \ln(R^L) + \alpha_F \ln(F)$

Adapted from Green & Mavor, 1994, p.126; Navy Recruiting Command (2007, p. 8).

The "Navy Recruiting Cost Model User Manual" refers to the enlistment supply functions as recruiting cost functions (Navy Recruiting Command, 2007, p.8). Smith and Hogan refer to these functions as the enlistment supply functions in "Modeling Cost and Performance for Military Enlistment, Report of a Workshop" (Green & Mavor, 1994, p.126). For the purpose of this research, the functions shown in Figure 3 are referred to as enlistment supply functions.

The objective function shown in Figure 4 determines "the levels of recruiting resources and incentives required to recruit the specified mission at minimum cost" (Green & Mavor, 1994, p. 127).

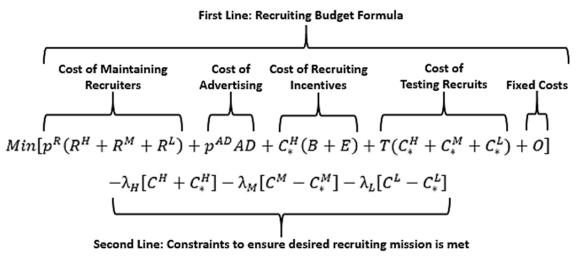
Figure 4. Recruiting Cost Minimization Problem

 $Min[p^{R}(R^{H} + R^{M} + R^{L}) + p^{AD}AD + C_{*}^{H}(B + E) + T(C_{*}^{H} + C_{*}^{M} + C_{*}^{L}) + 0]$ $-\lambda_{H}[C^{H} + C_{*}^{H}] - \lambda_{M}[C^{M} - C_{*}^{M}] - \lambda_{L}[C^{L} - C_{*}^{L}]$

Source: Green and Mavor (1994, p. 127).

An explanation of the components that makeup the recruiting "cost minimization problem" is shown in Figure 5.

Figure 5. Recruiting Cost Minimization Component Roadmap



Adapted from Green and Mavor (1994, p. 127).

The first order conditions of the recruiting minimization problem are then "substituted" into the recruiting budget formula (i.e., the first line of the recruiting cost minimization problem shown in Figure 5) to "yield the recruiting cost function," shown in Figure 6 (Green & Mavor, 127).

Figure 6. Recruiting Cost Function

$$\begin{aligned} \text{Minimum Cost Budget} &= \alpha Z(C_*^H)^{\frac{1+\alpha_B+\alpha_E}{\alpha}} + p^R \left[\left(\frac{C_*^M}{c_0^M} \right)^{\frac{1}{\alpha_R^M}} + \left(\frac{C_*^L}{c_0^L} \right)^{\frac{1}{\alpha_R^H}} \right] \\ &+ T(C_*^H + C_*^M + C_*^L) + 0 \end{aligned}$$

where:

$$Z = \left[(C_0^H)^{\frac{-1}{\alpha}}(v) \frac{\alpha_B + \alpha_E}{\alpha} \left(\frac{\alpha_R^H}{p^R} \right)^{\frac{-\alpha_R^H}{\alpha}} \left(\frac{\alpha_{AD}}{p^{AD}} \right)^{\frac{-\alpha_{AD}}{\alpha}} (\alpha_B)^{\frac{-\alpha_E}{\alpha}} (\alpha_E)^{\frac{-\alpha_E}{\alpha}} (F)^{\frac{-\alpha_F}{\alpha}} \right]$$

and $\alpha = \alpha_R^H + \alpha_{AD} + \alpha_B + \alpha_E$

Adapted from Green and Mavor (1994, p. 127).

Elasticities within the recruiting cost function are parameters built into the model that "represent the percent change in enlistment contracts for a percent change in recruiting resources/incentives or market factors" (McCloy et al., 1992, p. 74). The PRO model elasticities were last revised when the SAG Corporation and The Lewin Group, Inc. updated the PRO model in September 2011 (Hogan, Warner, & Mackin, n.d.). More information about the derivation and specifics of the cost performance tradeoff model can be found in the "Job Performance, and Cost: A Cost-Performance Tradeoff Model" report and "Modeling Cost and Performance for Military Enlistment," a report of a workshop (McCloy et al., 1992; Green & Mavor, 1994).

c. Model Framework

The PRO model is made up of four worksheets: (1) User Interface, (2) Inputs (will be referred to as the "Data Worksheet" in this research), (3) Simulation, and (4) Results. Figure 7 illustrates the conceptual flow and relationship between these worksheets.

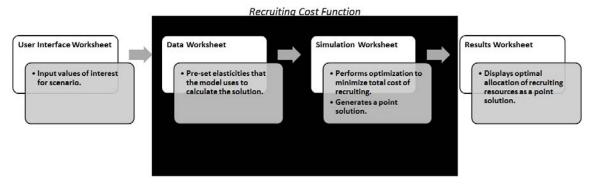


Figure 7. Structure of the PRO Model

The "User Interface" worksheet allows the user to enter values for each input variable, select which decision variables are fixed or to be optimized, and select how the model is run over seven FYs. The "Data Worksheet" and the "Simulation Worksheet" are components of the "black box" that makeup the

Adapted from Navy Recruiting Command (2007, p. 12).

recruiting cost function. The "Results Worksheet" provides users with the optimal mix of recruiting resources to minimize the cost of recruiting. Each component of the PRO model is now explained in more detail.

2. PRO Model Variables

The variables of the PRO model are classified into three types: (1) decision variables, (2) market factors, and (3) policy factors. Variables are fed into the model through PRO's "User Interface" Microsoft Excel worksheet, as shown in Figure 8.

Step 1: Check input								
	Model Feeds:	FY15	FY16	FY17	FY18	FY19	FY20	FY21
	NCF + College First	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	Unemployment Rate	6.40%	5.10%	4.90%	4.80%	4.80%	4.80%	4.80%
	Recruiters	3,913	3,685	3,685	3,685	3,685	3,685	3,685
	LRP	7.440	11.220	11.280	11.380	11.430	11.460	11.670
	Advertising (AC Enl. Only)	34.826	34.699	35.679	36.729	39.886	38.892	39.669
	EB	40.971	36.580	41.340	40.650	42.230	42.060	42.810
	NCO (50% BoY DEP)	35,025	36,425	36,800	35,800	35,225	34,650	34,650
Step 2: Select switches								
	Total Recruiters	Float						
Fixed	Advertising	Float						
Float	Bonus	Fixed						
	Education	Float						
Stap 2: Salact Bact/Mar	st Cases for Unemployment	POR +/- Range			Range (+/-)	0.50%		
Step 5. Select Dest/Wol	High UE Case	7.40%	6.10%	5.90%		5.80%	5.80%	5.80%
POR +/- Range	Base UE Case	6.90%	5.60%	5.40%		5.30%	5.30%	5.30%
Manual Forecast	Low UE Case	6.40%	5.00%	4.90%		4.80%	4.80%	4.80%
	Manual Forecast							
	High UE	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
	Consensus UE	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%
	Low UE	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
Stop 4: Soloct run turo								
Step 4. Select fun type	Traditional Dun			Capaci	ty Dun			
Step 4: Select run type	Traditional Run			Capaci	ty Run			

Figure 8. The PRO Model User Interface

POM FY17 version of the PRO model.

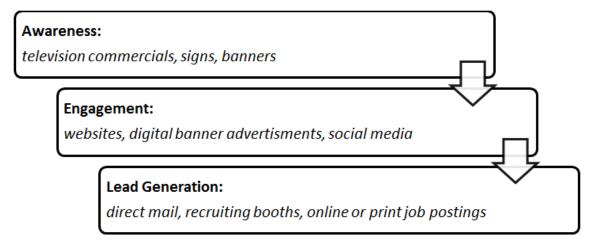
a. Decision Variables

The decision variables of the PRO model are the resources that the Navy controls. N1 can influence how much is budgeted toward advertising, how many production recruiters are in the field, and how funding is allocated for enlistment bonuses and education incentives. It is useful to know the optimal balance between these resources, since once money is allocated to a certain resource, those funds cannot be used for anything else. For example, funds appropriated for recruiters cannot be used to fund advertising (Morey & McCann, 1980, p. 1198).

(1) Advertising

Advertising is defined by the United States Government Accountability Office (GAO) as "the placement of messages intended to inform or persuade an audience through various types of media such as television, radio, digital media, direct mail, and others" (GAO, 2016, p. 1). Each military service, including the Navy, uses the advertising construct shown in Figure 9 to "raise the public's awareness... and help recruiters generate leads of potential recruits" (GAO, 2016, p. 1). A lead is someone who shows interest in joining the Navy. Leads can be generated a variety of ways, from face-to-face interactions with a recruiter to indirect contact through advertisement efforts.

Figure 9. Phases and Goals of Military Advertisement



Adapted from GAO (2016, p. 7).

Military advertising efforts are in line with the "consumer journey" construct found in the private sector. The goal is "to move a potential recruit through each phase and, ultimately, to a decision to enlist" (GAO, 2016, p. 7). The Navy typically allocates about \$50 million each FY towards advertising. Table 1 shows a breakdown of how much the Navy has annually allotted for advertising over the past three FYs in comparison to the other military services (GAO, 2016, p. 41).

	2015 Actuals	2016 Enacted	2017 Estimate
Navy	\$56,100,000	\$49,000,000	\$47,000,000
Army	\$367,700,000	\$238,100,000	\$292,600,000
Air Force	\$59,400,000	\$35,900,000	\$60,300,000
Marine Corps	\$86,300,000	\$81,500,000	\$81,800,000

Table 1. Reported Annual Allotments for Military Advertising

These values include active duty and reserve recruiting budgets. Adapted from GAO (2016, p. 41).

(2) Enlistment Bonus

Enlistment bonuses are used to incentivize high quality applicants to join the Navy. Enlistment bonuses are tied to specific Navy occupational specialties. Special warfare (Navy sea, air, and land (SEAL) operators) and nuclear field (NF) specialties are examples of Navy occupational specialties that require high ASVAB scores, and regularly offer an enlistment bonus to recruits. Figure 10 shows the individual enlistment bonus offered to each recruit who enlisted as a special operator or in the nuclear field. Enlistment bonuses fluctuate for many reasons, to include: the time of year the recruit ships to boot camp, and under or over manning strength of the Navy occupational specialty (Navy Recruiting Command, n.d.).

45000 40000 35000 Enlistment Bonus (\$) 30000 25000 Nuclear Field 20000 --- Special Operator 15000 10000 5000 0 Apr-01 Jan-04 Oct-06 Jul-09 Apr-12 Dec-14 Sep-17 Date

Figure 10. Enlistment Bonus Offered to NF and Special Operator Recruits

(3) Production Recruiters

Production recruiters are Navy Sailors assigned to recruiting duty with the 9585 Navy Enlisted Classification (NEC) code. For model simplicity, the PRO model divides production recruiters into three quality categories: low, medium, and high. The model designates high quality recruiters to recruit only high quality applicants, and so on. Navy Recruiting Command (NRC) does not separate recruiters into these tiered categories. This simplifying assumption helps represent that "high-quality personnel cost more to recruit" (Green & Mavor, 1994, p. 10–11).

The number of production recruiters in the field directly affects the total cost of recruiting. The PRO model takes recruiter's base pay and individual support costs into consideration when calculating the cost of recruiting.

(4) Education Incentive

Following the enactment of the Post 9/11 GI Bill in June of 2008, the Navy has not allocated funds towards the legacy Navy college fund (NCF) for new

Data gathered from Navy Recruiting Command enlistment bonus messages from October 2002 to February 2016. Adapted from Navy Recruiting Command (n.d.).

recruits (Dortch, 2014, p. 1; Palmer, personal communication, June 2016). The Post 9/11 GI Bill provides service members who have served on active duty following September 10, 2001, with education benefits that "can cover all in-state tuition and fees at public degree granting schools" along with support programs for out-of-state and private institutions (Department of Veterans Affairs, 2012).

b. Market Factors of the PRO Model

Market factors of the PRO model are economically and demographically driven variables that are uncontrollable and subject to unexpected change.

(1) Unemployment Rate

Unemployment rates are shown to be "positively and significantly related to high-quality enlistment contracts" (Asch et al., 2010, p. 21). As shown in Figure 8, this trend indicates that higher unemployment rates lead to more high quality enlistment contracts (Bicksler & Nolan, 2009, p. 5). Figure 11 shows data aggregated for all military services.

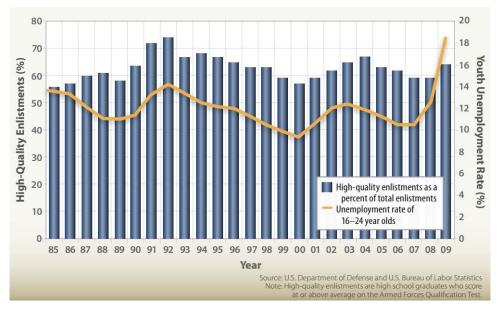


Figure 11. Unemployment and High-quality Enlistments

Source: Bicksler and Nolan (2009, p. 5).

(2) Relative Pay

Like unemployment rates, military recruiting for high quality applicants responds "to the level of military pay relative to civilian sector wage opportunities" (Warner, 2012, p. 71). The PRO model captures this market driver through the relative pay ratio. Since the Navy requires high quality Sailors who are technically competent, "pay comparability... is an issue for certain hard-to-fill occupations and skills that command high salaries in the civilian sector, particularly in high technology fields" (Bicksler & Nolan, 2009, p. 34). Table 2 provides interpretations of relative pay ratios.

Table 2. Interpretations of Relative Pay

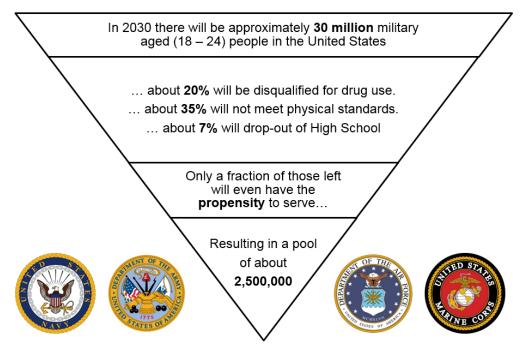
Relative Pay	Interpretation
0.5	Military pay is 50 cents to every dollar of civilian sector pay.
1.0	Military pay is equal to civilian sector pay.
2.0	Civilian sector pay is 50 cents to every dollar of military pay.

(3) Qualified Military Available

Qualified military available (QMA) is an estimate of the "17- to 24-year-old youth population in the United States who would qualify without needing a waiver and be available to enlist in the active component military" (Office of the Undersecretary of Defense, 2016, p. 2). An independent firm, Woods and Poole Economics, provides the Navy with QMA data (www.woodsandpoole.com).

Some common disqualifiers for applicants joining the military include: illicit drug use, overweight/obesity, use of prescribed psychotropic drugs, and failure to complete high school. Figure 12 is a hypothetical model which depicts the QMA pool for the recruiting efforts of the four military services. The resulting pool of QMA is just a small portion of the overall military-aged population within the United States.

Figure 12. Hypothetical Breakdown for Estimated QMA Pool in 2030



Data approximations are adapted from MarketingCharts (2016); Child Trends Data Bank (2014); Child Trends Data Bank (2016); National Center for Education Statistics (2016). Propensity to serve metric is omitted due to distribution restrictions.

Other factors that are not considered include the percentage of young adults who are currently enrolled in college, those who are permanently employed, or those who may have dependents.

c. Policy Factors of the PRO Model

Policy factors are variables that can be adjusted, but are done through a combination of policy, service culture, and budget changes.

(1) New Contract Objective

The new contract objective (NCO) is the Navy's enlisted accession mission for a given FY. NRC's NCO goal each FY is dependent on the Navy's projected end-strength. The equation for end-strength is shown in Figure 13.

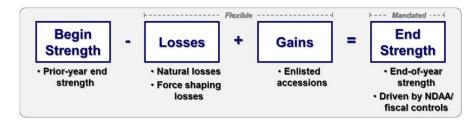


Figure 13. Equation for Navy Enlisted Strength Planning

Adapted from Dave Clark's 2015 presentation at the Naval Postgraduate School (personal communication, (September 10, 2015).

Force planners at N1 forecast the number of Sailors who will leave the Navy each year; referred to as manning losses. NRC's NCO goal ensures that the Navy's force strength meets the congressionally mandated end-strength for each FY (Clark, personal communication, 2015). Table 3 demonstrates the different phases of Navy manning within a FY. The NCO mission is dynamic and often fluctuates throughout the FY in response to actual manning losses.

Table 3. Navy Manning Terminology

Terminology	Description
Begin Strength	Current onboard as of October 1 of current FY
Force Strength	Current onboard anytime between October 2 and September 29 of current FY.
End Strength	Current onboard as of September 30 of current FY

The first day of the FY is October 1 and the last day of the FY is September 30.

(2) Loan Repayment Program

The loan repayment program (LRP) is an incentive that the Navy uses to attract high quality applicants with student loan debt to enlist in specific occupational specialties. Assuming enlisted service members with less than one year of service pursued higher education prior to joining the military, Figure 14 indicates that approximately 60 percent of recruits across all military branches have attended at least some college before joining the military. Figure 14 includes credits towards an undergraduate degree, a completed undergraduate degree, and postgraduate education.

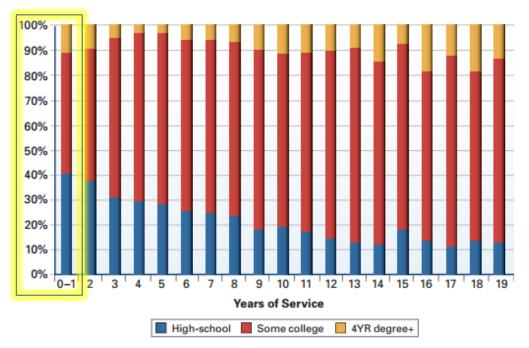


Figure 14. Education Levels of Enlisted Personnel

Assuming that service members who have between 0-1 year of service enlisted into the service with the education level shown. Source: Grefer, Gregory, and Rebhan (2011, p. 10).

Through the LRP, the Navy "pay[s] federally guaranteed student loans (up to \$65,000) through three annual payments during a Sailor's first three years of service" (Navy Recruiting Command, 2017). Student loan debt "is the only form of consumer debt that has grown since the peak of consumer debt in 2008," as shown in Figure 15 (Lee, 2013, p. 5).

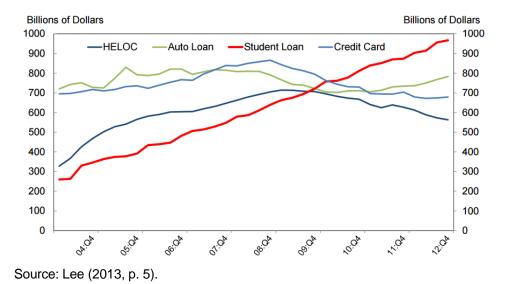


Figure 15. Rise of Student Debt

Consequently, the military's loan repayment program may be an attractive option for a high quality recruit with student loan debt.

(3) High School Diploma

Studies indicate that a high school diploma is "a valuable predictor of military attrition" (Buddin, 1984, p. 2). Recruits who do not have a high school diploma are more likely to not finish their initial obligated military service. In response to this "well-known result," the DOD has a benchmark that at least 90 percent of new accessions must join the military with a high school diploma (Navy Recruiting Command, 2007, p. 7; Buddin, 1984, p. 1). A general education development (GED) certificate is not considered a high school diploma (Buddin, 1984, p. 1).

(4) Recruit Quality

Recruit quality is determined by an applicant's Armed Forces Qualification Test (AFQT) score. The AFQT score is derived from the ASVAB's "Arithmetic Reasoning (AR), Mathematics Knowledge (MK), Paragraph Comprehension (PC), and Word Knowledge (WK)" subsections (Defense Management Data Center, n.d.). High school graduates who earn above a 50 AFQT are classified as "high quality" applicants (Navy Recruiting Command, 2007, p. 6). The term high quality is also referred to as Test Score Category (TSC) I-IIIA. This group is represented by the "A" block in Figure 16.

AFQT	TSC	High School Diploma	No High School Diploma			
99 - 93	I					
93 - 65	Ш	Α	В			
65 - 50	IIIA					
50 - 31	IIIB	Cu	6			
	IVa	0	U			
31 - 0	IVb	L L				
	IVc					
	v	DOD Ineligible				

Figure 16. Navy Recruit Quality Determination

Adapted from Navy Recruiting Command (2007, p. 7).

The Navy aims to recruit applicants who meet the group "A" requirement because they qualify for most Navy occupational specialties, have the lowest first term attrition rate, historically encounter fewer disciplinary problems, and are likely to have the best career performance. However, this category of applicants tends to be the most expensive to recruit (Navy Recruiting Command, 2007, p. 7).

High quality applicants typically have multiple opportunities, such as college or a well-paying job. Therefore, the Navy must invest more money in advertisements targeting group "A," increase enlistment bonuses to incentivize group "A," and increase recruiting manpower to recruit group "A" applicants. Each of these contribute to the high cost of recruiting high quality applicants.

Descriptions and characteristics of all categories represented in Figure 16 are explained in Table 4.

Block/Category	Description
А	(1) Qualify for the most amount of programs
	(2) Have the lowest first term attrition
	(3) Encounter fewer disciplinary problems
	(4) Likely to have the best career performance
В	(1) Highest first term attrition rate
	(2) Qualify for many programs
Cu	(1) Attrition lower than "B," but higher than "A"
	(2) Applicants do not qualify for many programs.
CI	Navy does not recruit from this group
D	Navy does not recruit from this group

Table 4. Recruit Quality Category Description

Adapted from Navy Recruiting Command (2007, p. 7).

d. PRO Model: Run Options

PRO model excursions can be run two different ways; (1) traditional run, or (2) capacity run.

(1) Traditional Run

The traditional run option of the PRO model performs an optimization that minimizes the cost of recruiting by determining the optimal allocation of resource spending to advertisements, enlistment bonuses, education incentives, and recruiters. The traditional run can be evaluated as either an unconstrained or a constrained problem.

An unconstrained traditional run does not bound any of the decision variables. The result is "an unconstrained, minimum cost solution" (Navy Recruiting Command, 2007, p. 22). Unconstrained traditional runs may produce results that are mathematically feasible, but are infeasible in practice. For example, while it would be unrealistic for NRC to have more than 4,000 recruiters in the field, the PRO model may determine 4,520 recruiters to be the optimal solution.

Figure 17 shows the results of an unconstrained traditional run of the PRO model. The highlighted rows are the results. In FY 2015, with a 5 percent unemployment rate, and a recruiting mission of 34,000, the optimal allocation of

recruiting resources to minimize the cost of recruiting was: assign 3,137 Sailors to recruiting duty, allocate \$50,960,000 to advertising, and \$67,267,000 to enlistment bonuses.

	Resource Run	2015	2016	2017	2018	2019	2020	2021
	NCO	34,000	34,000	34,000	34,000	34,000	34,000	34,325
	Capacity	N/A						
	Unemployment (%)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Float	Total Recruiters	3,137	3,132	3,125	3,117	3,110	3,101	3,141
	Total Recruiter Cost (\$M)	\$256.944	\$259.364	\$262.626	\$265.932	\$269.281	\$273.186	\$281.505
Float	Advertising (\$M)	\$50.960	\$51.329	\$51.798	\$52.272	\$52.750	\$53.293	\$55.170
Float	Enlistment Bonus (\$M)	\$67.267	\$67.754	\$68.374	\$68.999	\$69.630	\$70.346	\$72.825
Float	Education Incentives (\$M)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
	LRP (\$M)	\$7.440	\$11.220	\$11.280	\$11.380	\$11.430	\$11.460	\$11.670
	HSDG	95%	95%	95%	95%	95%	95%	95%
	TSC I-IIIA	70%	70%	70%	70%	70%	70%	70%
	Total Cost (\$M)	\$382.611	\$389.667	\$394.078	\$398.583	\$403.091	\$408.285	\$421.170

Figure 17. Results of an Unconstrained PRO Model Run

POM FY17 version of the PRO model.

In contrast, a constrained traditional run fixes at least one of the four decision variables. The decision variables that are fixed remain constant. The remaining unconstrained decision variables are optimized (Navy Recruiting Command, 2007, p. 22).

Figure 18 demonstrates the results of a constrained traditional PRO model run where advertising and enlistment bonus were fixed and the total number of recruiters was optimized.

	Resource Run	2015	2016	2017	2018	2019	2020	2021
	NCO	34,000	34,000	34,000	34,000	34,000	34,000	34,325
	Capacity	N/A						
	Unemployment (%)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Float	Total Recruiters	3,037	3,042	3,047	3,052	3,058	3,063	3, 151
	Total Recruiter Cost (\$M)	\$248.724	\$251.880	\$256.097	\$260.386	\$264.747	\$269.825	\$282.408
Fixed	Advertising (\$M)	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000
Fixed	Enlistment Bonus (\$M)	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500
Float	Education Incentives (\$M)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
	LRP (\$M)	\$7.440	\$11.220	\$11.280	\$11.380	\$11.430	\$11.460	\$11.670
	HSDG	95%	95%	95%	95%	95%	95%	95%
	TSC HIIA	70%	70%	70%	70%	70%	70%	70%
	Total Cost (\$M)	\$383.664	\$390.600	\$394.877	\$399.266	\$403.677	\$408.785	\$421.578

POM FY17 version of the PRO model.

The highlighted rows are the results. In FY 2015, with a 5 percent unemployment rate, a recruiting mission of 34,000, advertising fixed at \$60,000,000, and enlistment bonuses fixed at \$67,500,000, the Navy should assign 3,037 Sailors to recruiting duty.

(2) Capacity Run

The capacity run estimates the number of recruits the Navy can expect to recruit based on a predetermined allocation of recruiting resources. Figure 19 exhibits the results of a capacity run.

Capacity Run	2015	2016	2017	2018	2019	2020	2021
NCO	34,000	34,000	34,000	34,000	34,000	34,000	34,325
Capacity	33,426	33,405	33,385	33,364	33,344	33,324	33,303
Unemployment (%)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Total Recruiters	2,900	2,900	2,900	2,900	2,900	2,900	2,900
Total Recruiter Cost (\$M)	\$237.520	\$240.119	\$243.725	\$247.381	\$251.093	\$255.477	\$259.917
Advertising (\$M)	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000	\$60.000
Enlistment Bonus (\$M)	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500	\$67.500
Education Incentives (\$M)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
LRP (\$M)	\$7.440	\$7.440	\$11.220	\$11.280	\$11.380	\$11.430	\$11.460
HSDG	95%	95%	95%	95%	95%	95%	95%
TSC I-IIIA	70%	70%	70%	70%	70%	70%	70%
Total Cost (\$M)	\$372.460	\$375.059	\$382.445	\$386.161	\$389.974	\$394.407	\$398.877

Figure 19. Results of a Capacity PRO Model Run

POM FY17 version of the PRO model.

The results indicate that in FY 2015 the Navy can expect 33,426 recruits with 2,900 recruiters in the field, \$60,000,000 allocated to advertising, and \$67,500,000 allocated to enlistment bonuses.

3. Updates to the PRO Model

In 2011 the SAG Corporation and The Lewin Group, Inc. updated the PRO model based on specific shortcomings of the model identified by the Navy (Hogan et al., n.d., p. 1). The updated model is referred to as the Recruiting Program Resource Optimization (E-PRO) model. The E-PRO model added "stochastic forecasting capability" and updated the econometric elasticities within the recruiting cost function (Hogan et al., n.d., p. 3).

Despite these updates, analysts at N1 still use the PRO model since it is "simpler in construct [compared to E-PRO]... and delivers very good results" (Palmer, personal communication, April 7, 2016). As mentioned earlier, the current version of the PRO model uses "the pooled baseline elasticities updated from the... [2011] E-Pro effort" (Palmer, personal communication, April 12, 2016).

4. Limitations of the PRO Model

The existing PRO model does not have the capability to efficiently test uncertainties in variable values, or the effects of variable interactions. Without this capability, PRO model users must use either manual trial and error techniques to test different scenarios individually, or build macros in Excel to test the fluctuation of a single variable. For example, a macro was written to test three levels of unemployment rate, as shown in Table 5.

	FY 15	FY16	FY17	FY18	FY19	FY 20	FY21
High UE	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Base UE	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%
Low UE	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%

Table 5. Pooled Unemployment Rates

Adapted from POM FY17 version of the PRO model.

Without options for multivariable sensitivity analysis or efficient experimentation, it is difficult to understand how variable interactions or fluctuations in controllable and uncontrollable factors affect the model's output. This may be an area of concern when the output is used to help inform decisions involving hundreds of millions of dollars.

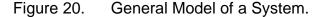
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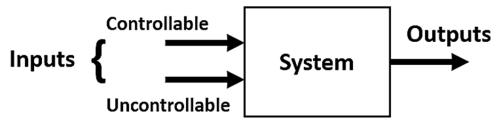
III. METHODOLOGY AND IMPLEMENTATION

This chapter covers three main topics that span the motivation, design, and implementation of PROM-WED. First, an overview of design of experiments techniques is presented. Next, the field of data farming is introduced to include examples of past research studies that have utilized data farming. Finally, these two concepts are integrated as the design and construction of PROM-WED is explained.

A. DESIGN OF EXPERIMENTS

The objective of an experiment across any discipline of study is "to investigate characteristics of a system" (Park, 2007, p. 309). There are no limits to what this system can be, from the test and evaluation of a new military warship, to sensitivity analysis on a political science poll. Every system has inputs and outputs. Inputs are either controllable or uncontrollable. Controllable factors are input variables to the system that are known and can be set, such as the number of Navy destroyers that enter a theater of operations in a combat simulation, to the number of production recruiters Navy Recruiting Command has in the continental United States. Uncontrollable factors are input variables to the system that are uncertain, such as the unemployment rate in 2021, or the probability of kill for an adversary's new weapon system. A general model of a system is shown in Figure 20.







Early development in DOE methodology occurred predominately in the physical sciences, specifically in agriculture (Penn State, n.d.). The classical methods and foundations of DOE can also be applied to the testing and analysis of simulation models (Sanchez, 2006, p. 69). Control, replication, and randomization are considered to be "fundamental concepts" of DOE (Sanchez, 2006, p. 69). Working definitions of these concepts in the context of DOE are shown in Table 6.

Table 6.	Fundamental	Concepts of DOE.
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Fundamental Concept	Working Definition
Control	"The experiment is conducted in a systematic manner after explicitly considering potential sources of error, rather than by using a trial-and-error* approach. "
Replication	"A way to gain enough data to achieve narrow confidence intervals and powerful hypothesis tests."
Randomization	"Provides a probabilistic guard against the possibility of unknown, hidden sources of bias surfacing to create problems with your data."

Adapted from Sanchez (2006, 69).

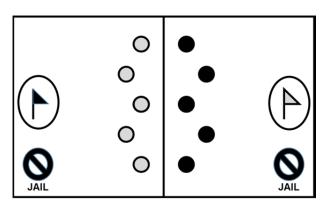
To adequately test a system, whether the system is a simulation model or a physical science experiment, trial-and-error should be avoided. Trial-and-error is inefficient, difficult to replicate, and lacks control. DOE techniques combat these limitations through systematically testing a model with control, replication, and randomization. Systematic approaches are also conducive for automation, which alleviates manual work, and increases the efficiency and capability of the system being explored. The automation of DOE techniques has created the field of data farming, which is further explained in the next section.

There are many different DOE methods and techniques available, such as the full and fractional factorials, central composite designs, and nearly orthogonal Latin hypercubes (NOLHs). The full factorial and NOLH methods are explained in further detail. More information regarding DOE basic concepts, methods and their application to simulation modeling can be found in Sanchez and Wan's report, "Work Smarter, Not Harder: A tutorial on designing and conducting simulation experiments" (Sanchez & Wan, 2015).

1. Full Factorial DOE Method

The full factorial approach tests every possible combination of input factors given fixed levels. The classic game of "capture the flag" is used to explain the full factorial method. The objective of the game is for a member of one team to capture a flag that is kept on the other side of the field, and return it to their side of the field. If caught by a member of the opposing team on the opposition's side of the field, the player fails the mission, and is temporarily placed in "jail." Figure 21 shows a simple representation of the "capture the flag" game, where the gray team on the left is trying to capture the gray flag on the opposition's side, and vice versa.

Figure 21. Capture the Flag Game



The circles represent the players of each team. Adapted from MultiCulturalGames (n.d.).

Two attributes that may affect the success of a "capture the flag" player are speed and stealth. Figure 22 illustrates the testing of various degrees of speed and stealth for a "capture the flag" player. The sparse grid on the left tests the system only at its extreme values, where either minimum speed or minimum stealth results in a failure, but maximum speed and maximum stealth results in a success. The grid on the right demonstrates a dense full factorial test where many possible levels of stealth are tested against many possible levels of speed. In this hypothetical example, success can be met at something other than a combination of full speed and full stealth (Sanchez & Wan, 2015, p. 1801).

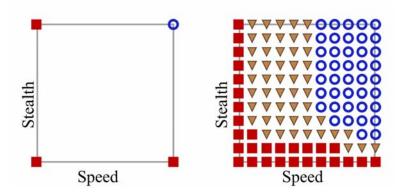


Figure 22. A Sparse versus a Dense Full Factorial DOE for Capture the Flag

The dense full factorial grid in Figure 22 illustrates two key advantages that DOE techniques can offer: (1) space-filling capability, and (2) robust insight and understanding of the solution space.

Space-filling refers to a DOE's capability of testing the simulation over a broad spectrum of input combinations (Sanchez & Wan, 2015). Figure 22 demonstrates that testing only the maximum and minimum values does not have good space-filling capability, whereas using the multi-level full factorial DOE exemplifies high space-filling capability. The ability to test a factor at different levels increases the potential insight gained from the solution space (Sanchez & Wan, 2015). As demonstrated in Figure 22, the space-filling DOE provides insight to capture the flag players that the right combination of stealth and speed resources can achieve the target solution using less resources. Full factorial DOEs are orthogonal, which means that there are no confounding effects.

The block shapes indicate failure, whereas the circle indicates success. The triangle represents a result somewhere in between failure and success. Source: Sanchez and Wan (2015, p. 1801).

Certain combinations of input variables, such as speed and stealth, may influence the effect of each other. This is referred to as a variable interaction. Variable interactions identify "whether the levels of some factors influence the effects that other factors have" on the solution (Sanchez & Wan, 2015, p. 1796). Without proper care in designing experiments, interactions can be impossible to estimate.

Time and computing capability can quickly become limiting factors when performing DOE tests on complex simulation models. Testing a complex model using a full factorial of all possible combinations of variables is inefficient and often inconceivable. For example, Table 7 demonstrates how a DOE that examines a model with only 20 factors can quickly become infeasible as the number of levels increases.

Number of levels each factor is studied at	Equation	Number of Experiments Required
2 (i.e., only a min and max value)	2 ²⁰	1,048,576
4 (i.e., min, max and 2 values in between)	4 ²⁰	1,099,510,000,000
6 (i.e., min, max and 4 values in between)	6 ²⁰	365,616,000,000,000

Table 7. Number of Experiments Required to Test a Model with 20Factors Using Full Factorial Designs

Adapted from Sanchez (2006, p. 76).

Increasing the number of experiments becomes costly since more experimental runs require higher computing capability, and increased work hours.

2. Nearly Orthogonal Latin Hypercubes

Cioppa and Lucas (2007) developed the nearly orthogonal Latin hypercubes (NOLH) which are efficient and effective alternatives to the full factorial DOE. "Latin hypercube designs have proven useful for exploring complex, high-dimensional computational models, but can be plagued with unacceptable correlations among input variables" (Hernandez, Lucas, & Carlyle, 2012, p. 1). Cioppa and Lucas' work addresses this problem by "inducing small correlations between the columns in the design matrix" (2007, p. 45). The result is the nearly orthogonal Latin hypercube. These NOLH DOEs provide analysts with many advantages, including the ability:

to determine the driving factors, detect interactions between input variables, identify points of diminishing or increasing rates of return, and find thresholds or change points in localized areas... [and] fit many diverse metamodels to multiple outputs with a single set of runs. (MacCalman, Vieira, & Lucas, 2016, p. 1)

Figure 23 shows a comparison of space-filling capabilities between two full factorial designs (A and B), versus two NOLH designs (C and D). The four designs are respectively a 2^4 and a 4^4 full factorial designs, and a 17-point and 257-point NOLH DOEs.

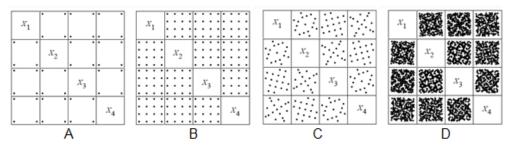


Figure 23. Pairwise Plot Matrices of DOE Designs

Source: Sanchez and Wan (2015, p. 1802).

Table 8 provides a numerical representation of the four DOE designs shown in Figure 23. For one extra design point (i.e., 16 to 17, or 256 to 257), we get much greater space filling with the NOLH DOE.

Pairwise Plot Matrix	Design	Factors	Levels	Design Points
A	2 ⁴ Factorial	4	2	16
В	4 ⁴ Factorial	4	4	256
С	NOLH	7	17	17
D	NOLH	29	257	257

 Table 8.
 Factorial Designs versus NOLH Designs

Adapted from Sanchez and Wan (2015, p. 1802).

As demonstrated by Figure 23 and Table 8, the NOLH designs minimize computational effort while improving space-filling capability, allowing for more factors to be tested within the same experimental design (Sanchez & Wan, 2015, p. 1803). At the cost of one additional design point, we are able to analyze 7 or 29 factors at 17 and 257 levels, respectively, in comparison to a factorial design with 4 factors at either 2 or 4 levels. Reference Cioppa and Lucas' paper "Efficient Nearly Orthogonal and Space-filling Latin Hypercubes" for more information about the NOLH DOE method (Cioppa & Lucas, 2007).

From the initial research done by Cioppa and Lucas, other families of NOLH designs have been developed to enhance and make the NOLH designs adaptable to further applications in simulation analysis. To expand the NOLH designs capability a mixed integer program (MIP) algorithm was developed "that generates Latin hypercubes with little or no correlation among their columns for most any determinate run-variable combination" (Hernandez et al., 2012, p. 1). This MIP algorithm is also adaptable and accommodating to run modifications. (Hernandez et al., 2012, p. 1). A second-order NOLH design has also been developed that facilitates "exploratory analysis of stochastic simulation models in which there is considerable a priori uncertainty about the forms of the responses" (MacCalman et al., 2016, p. 1). Lastly, Sanchez created a Microsoft Excel spreadsheet that uses Cioppa and Lucas' NOLH DOE algorithm to provide users with the ability to generate designs ranging from simple small orthogonal Latin hypercubes to complex NOLH designs that handle up to 29 factors at 257 levels

each (Sanchez, 2011). These designs, along with other DOE methods, are available in Microsoft Excel format at <u>https://harvest.nps.edu.</u>

B. DATA FARMING

Work smarter, not harder...

-Professor Susan Sanchez (2006)

The use of robust design of experiment techniques has spawned a field of data analytics for simulation models, referred to as data farming. In comparison to traditional methods such as data mining, where one "seek[s] to uncover valuable nuggets of information buried within massive amounts of data," data farming grows data by controlling the interactions of the variables through efficient DOE techniques (Sanchez, 2014, p. 800). Retrospective data collection can find correlations, but prospective DOE is required to establish causality.

Data farming is an iterative process that allows analysts to gain robust insight into the "big picture' solution landscape" (Horne & Meyer, 2010, p. 1). Six foundational components of data farming are shown in Figure 24.

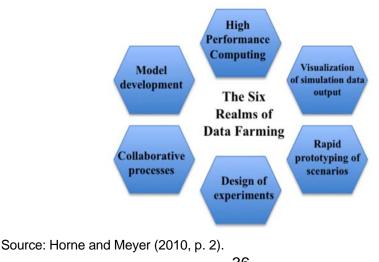


Figure 24. The Six Realms of Data Farming

³⁶

Steve Upton of the SEED center at NPS has built multiple data farming wrappers to facilitate efficient DOE testing around simulation models spanning diverse computing environments and subject areas. The data farming wrappers that he builds are computer programs that wrap a DOE algorithm around a preexisting model. The following is a sample of research that utilizes Upton's data farming wrappers:

- Erin Borozny tested the Navy's Officer Strategic Analysis Model (OSAM) using data farming. OSAM is a manpower model that projects officer end strength and force structure based on "personnel plans and force-shaping policy" (Borozny, 2015, p. v). Her research provides insight into effective ways the Navy can better manage its officer inventory in order to meet authorized end strength at the end of each FY (Borozony, 2015).
- Christian Seymour applied data farming to the Synthetic Theater Operations Research Model (STORM). The Department of Defense uses STORM as its "primary campaign analysis tool" that considers "force structures, operational concepts, and military capabilities" (Seymour, 2014, p. v). His study shows that data farming "capitalize[s] on STORM's full potential" and provides policy makers with robust insights in an efficient and effective manner (Seymour, 2014, p. v).
- 3. Jeffery Parker's research on the Marine Corps' future amphibious capability used data farming around a model that simulated amphibious assaults. His research provides informative decision support for United States Navy procurement "by evaluating the [Marine Expeditionary Unit's] MEU's expeditionary amphibious assault capability and the use of ship-to-shore connectors" (Parker, 2015, p. v).

These are only three examples of numerous studies that have utilized a data farming wrapper around a simulation model. They demonstrate how adaptable, capable, and valuable data farming an existing model can be. For more information about studies that have used data farming in defense applications, visit <u>https://harvest.nps.edu</u>.

C. PROM-WED

PROM-WED was developed to provide analysts with a tool that evaluates the PRO model over scenarios constructed using the NOLH DOE algorithm. PROM-WED also provides analysts with decision support capabilities that capitalize on its ability to grow data, and perform sensitivity and risk analysis to better inform decision makers on a robust solution to the optimal allocation of recruiting resources. PROM-WED excursions can be run to model the effects of varying degrees of policy changes and a range of economic and demographic conditions that affect the total cost of recruiting. One PROM-WED excursion provides decision support analysis to cover the effects of all of these factors and their interactions with one another.

To achieve these objectives, PROM-WED is divided into three main components: (1) the NOLH DOE data farming wrapper, (2) the GUI, and (3) decision support analysis. For the purpose of this research, focus is placed on the traditional run option. Refer to Chapter V regarding the capacity run option.

Since the PRO model is built in Microsoft Excel, PROM-WED is also built in Microsoft Excel, specifically Microsoft Excel 2013 Version 15.0.4849.1003 (Microsoft Excel, 2013). Given the restrictions and limitations of software allowed on government computers, maintaining PROM-WED in the Microsoft Excel environment allows accessibility of use to any government computer without requiring any additional software.

1. Data Farming Wrapper

The NOLH DOE algorithm is the foundation of PROM-WED's data farming wrapper. The NOLH was chosen for its space-filling capability and ease of use in a Microsoft Excel VBA modeling environment. The SEED Center at NPS has made the NOLH DOE algorithm available in a Microsoft Excel worksheet at https://harvest.nps.edu.

PROM-WED's data farming wrapper uses both the 33-point and 129-point NOLH design worksheets. The 33-point design tests up to 11 variables at 33

levels, whereas the 129-point design tests up to 22 variables over 129 levels. The 129-point design has better space-filling properties, but takes more time to run. Figure 25 shows a pairwise plot comparison of the space-filling ability of these two designs. The user is able to choose which NOLH design they want to run excursions over using the GUI that is further explained in the next section.

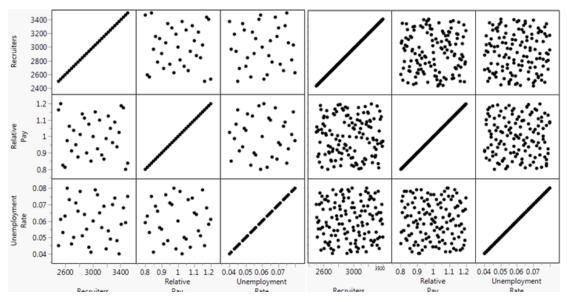


Figure 25. Pairwise Plots for the 33 and 129 Point NOLH Designs

Left: 33-point NOLH DOE. Right: 129-point NOLH DOE.

Table 9 shows an example PROM-WED test case scenario.

Table 9.	Example PROM-WED Scenario	
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Variable Type	Variable Name	Value Low	Value High
Decision Variable	Production Recruiters	2,500 recruiters	3,500 recruiters
Market Factor	Unemployment Rate (UE)	4.0%	8.0%
Market Factor	Relative Pay	0.8	1.2
Policy Factor	Recruiting Mission (NCO)	30,000 recruits	40,000 recruits

Figure 26 shows the implementation of this scenario in the 33-point NOLH design worksheet. A 129-point NOLH design worksheet can be found in

Appendix A. Each FY that is explored has its own worksheet similar to the one seen in Figure 26 for FY 2017. PROM-WED provides users with a recruiting resource allocation over seven FYs. Therefore, there are seven 33-point NOLH design worksheets and seven 129-point NOLH design worksheets within PROM-WED's data farming wrapper.

	А	В	С	D	E	F	G	Н		J	K	L
1	low level	0.0001	0.04	2500	11.28	34.8264	40.97	30000	0.7	0.95	0.8	1883304
2	high level	0.0001	0.08	3500	11.28	34.8264	40.97	40000	0.7	0.95	1.2	1883304
3	decimals	4	3	0	3	3	3	0	2	2	6	0
4	factor name	NCF + College First	Unemployment Rate	Recruiters	LRP	Advertising (AC Enl. Only)	EB	NCO (50% BoY DEP)	TSC I-IIIA	HSDG a	tive Pay	QMA
5		0.0001	0.044	2938	11.28	34.826	40.97	36875	0.7	0.95	1.075	1883304
6	FY	0.0001	0.08	2625	11.28	34.826	40.97	37500	0.7	0.95	0.975	1883304
7	2017	0.0001	0.058	3406	11.28	34.826	40.97	37188	0.7	0.95	1.1875	1883304
8		0.0001	0.075	3500	11.28	34.826	40.97	38125	0.7	0.95	0.8375	1883304
9		0.0001	0.041	2969	11.28	34.826	40.97	34063	0.7	0.95	0.85	1883304
10		0.0001	0.078	2813	11.28	34.826	40.97	31563	0.7	0.95	1.0125	1883304
11		0.0001	0.059		11.28	34.826		33750	0.7	0.95	0.8	1883304
12		0.0001	0.068		11.28	34.826		32188	0.7	0.95	1.175	1883304
13		0.0001	0.05		11.28	34.826		30000	0.7	0.95	1.0375	1883304
14		0.0001	0.066		11.28	34.826		30938	0.7	0.95	0.875	1883304
15		0.0001	0.049		11.28	34.826		31250	0.7	0.95	1.05	1883304
16		0.0001	0.069		11.28	34.826		34688	0.7	0.95	0.8625	1883304
17		0.0001	0.046		11.28	34.826		39688	0.7	0.95	0.9125	1883304
18		0.0001	0.064		11.28	34.826		39375	0.7	0.95	1.1125	1883304
19		0.0001	0.048		11.28	34.826		36563	0.7	0.95	0.9375	1883304
20		0.0001	0.065		11.28	34.826		35625	0.7	0.95	1.1	1883304
21		0.0001	0.06		11.28	34.826		35000	0.7	0.95	1	1883304
22		0.0001	0.076		11.28	34.826		33125	0.7	0.95	0.925	1883304
23		0.0001	0.04		11.28		40.97	32500	0.7	0.95	1.025	1883304
24		0.0001	0.063		11.28	34.826		32813	0.7	0.95	0.8125	1883304
25		0.0001	0.045		11.28	34.826		31875	0.7	0.95	1.1625	1883304
26 27		0.0001	0.079		11.28 11.28	34.826 34.826		35938 38438	0.7 0.7	0.95 0.95	1.15 0.9875	1883304 1883304
28		0.0001	0.043		11.20	34.826	40.97	36250	0.7	0.95	0.9075	1883304
20		0.0001	0.061			34.826	40.97	37813	0.7	0.95	0.825	1883304
30		0.0001	0.053		11.20		40.97	40000	0.7	0.95	0.9625	1883304
31		0.0001	0.07		11.20	34.826		39063	0.7	0.95	1.125	1883304
32		0.0001	0.054		11.20	34.826		38750	0.7	0.95	0.95	1883304
33		0.0001	0.051		11.28	34.826		35313	0.7	0.95	1.1375	1883304
34		0.0001	0.074		11.28	34.826		30313	0.7	0.95	1.0875	1883304
35		0.0001	0.056		11.28	34.826		30625	0.7	0.95	0.8875	1883304
36		0.0001	0.073		11.28	34.826		33438	0.7	0.95	1.0625	1883304
37		0.0001	0.055		11.28	34.826		34375	0.7	0.95	0.9	1883304

Figure 26. Scenario Inputted into the NOLH Worksheet

Figure 26 illustrates that each input, whether it be a controllable or uncontrollable variable, is tested over 33 levels. Recruiting mission, number of recruiters, UE, and relative pay are the variables that are tested over a range of values. The lower bound on the range is fed into the "low level" cell, whereas the upper bound on the range is fed into the "high level" cell. For the variables that remain constant, the low and high values are the same. The "decimals" cell refers to the number of significant digits in the decimal place that the NOLH algorithm divides the factor into. For example, recruiters, NCO, and QMA variables all have a zero in the "decimals" cell since these variables represent people, and having a fraction of a person is infeasible. Each row of the worksheet shown in Figure 26 represents a different scenario. A subroutine loops over each row of the worksheet and feeds the values for each input variable into the legacy PRO model. The subroutine that executes 33 design point NOLH excursions can be found in Appendix B. The legacy PRO model's "RunTraditional" macro was adapted to accommodate data farming. The modified macro is now referred to as "RunTraditional6."

A 33-design point NOLH design will result in 33 different legacy PRO model solutions, and a 129-design point NOLH design will result in 129 different legacy PRO model solutions. The NOLH worksheet married with the subroutine makes up the data farming wrapper.

2. Graphical User Interface

PROM-WED's GUI makes data farming easily accessible to any PRO model user regardless of knowledge or skill in DOE techniques or data farming. A snapshot of PROMWED's GUI is shown in Figure 27.

Planned Resource Optimization Model with Experimental Design (PROM-WED)							
Start in FY	Saved Scenarios:	•					
Set Variables Decision Variables NCF + College First Recruiters Advertising (AC Enl. Only) EB	Fix DV Select to Test	Values Fix Value	Variable Set Fixed Decision Variables				
Market Factors Relative Pay QMA TSC 1-IIIA HSDG Unemployment Rate Unemployment Rate	Single Value Add MF Select to Test Range of Values	Set Range Remove	Varied Market Factors Fixed Market Factors				
Base Low	High Decimal Level Places		Analysis Options				
FY Value Level			Select Run Type Design of Experiments Traditional Run 33 Design Points 129 Design Points 129 Design Points				
			Include output for analysis in JMP				
			Save Scenario Name Scenario Run				
			NOLH Run Select to run space-filling, DOE excursions Cancel				

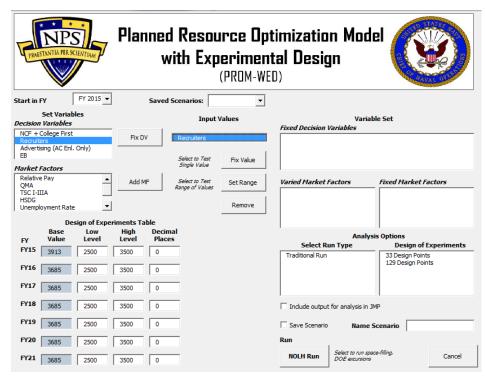
Figure 27. PROM-WED's GUI

The variables are categorized as either "Decision Variables" or "Market Factors." A decision variable can either be constrained ("Fixed") or unconstrained ("Floated"). The title "Market Factors" is a blanket category that covers both market factors, as well as policy factors, as described in Chapter II.

A brief description of how a PROM-WED excursion is performed using the GUI is now presented. A detailed PROM-WED user manual can be found in Appendix C.

To constrain a decision variable, select the variable of interest and click on "Fix DV." A constrained decision variable can either be fixed as a constant or tested over a range of values using the NOLH algorithm. If the user is interested in testing over a range, the desired lower and upper bounds of the range are inputted into the "Design of Experiments Table," as shown in Figure 28.



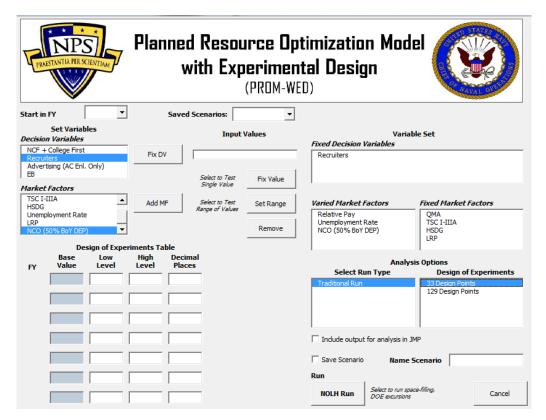


Number of recruiters is being tested over a range of 2,500 to 3,500 for each FY of this excursion.

Each "low level" and "high level" value of the "Design of Experiments Table" is linked to a NOLH worksheet. For example, the low and high values for FY 17 are linked to the NOLH worksheet for FY 2017, as shown previously in Figure 26.

A similar procedure is followed for each variable listed in the "Market Factors" category. The user must work through each variable in the "Market Factors" list, and choose whether it is kept constant ("Fix Value"), or tested over a range of values ("Set Range"). The NOLH DOE is complete once all variables listed in the "Market Factors" category are accounted for. Once the NOLH is fully populated, as shown in Figure 29, the user selects the "Run Type," and the number of design points the NOLH is tested over. Currently PROM-WED has the capability to test the traditional run option. Further work is required for the capacity run option.

Figure 29. PROM-WED GUI when NOLH is Fully Populated



Selecting the "NOLH RUN" button executes the subroutine to begin growing the data. The 33-point design takes approximately two minutes to run on a standard modern personal computer (PC), whereas the 129-point design takes about five to ten minutes to run. Run times are dependent on factors such as the operating system and computational capacity of the computer. The result for each PROM-WED scenario is deposited to a worksheet for further analysis.

3. PROM-WED Decision Support Analysis

In addition to growing PRO model data using data farming, PROM-WED provides users with decision support capabilities to analyze the data grown by each excursion. PROM-WED offers two decision support capabilities: (1) automatically generated analysis and (2) data generated for further analysis requiring a statistical software package. In this section, PROM-WED's decision support capabilities are discussed. The focus is on why each type of graph or table was chosen. Chapter IV has a detailed discussion dedicated to analyzing PROM-WED's decision support capability.

a. Automatically Generated Decision Support Capability

The purpose of PROM-WED's automatically generated decision support analysis is to provide users with a tool capable of providing an at-a-glance understanding of the solution space of a completed PROM-WED excursion. PROM-WED's "Decision Support Analysis" for the traditional run option provides users with a broad understanding of how variability in decision variables, controllable policy changes, and uncontrollable market factors affect the total cost of recruiting. Since the traditional run addresses the allocation of resources (i.e., the decision variables), the automatically generated decision support capability provides at-a-glance insights to decision makers regarding the optimal allocation of recruiting resources using the 33-point design. In the next section, further insights regarding variable interactions and the effects of the various market factors are explored using a commercial statistical software package. In an effort to provide as much relevant information as possible within an easily printed worksheet, Figures 30 and 31 show the two pages that comprise PROM-WED's automatically generated decision support capability for the traditional run option.

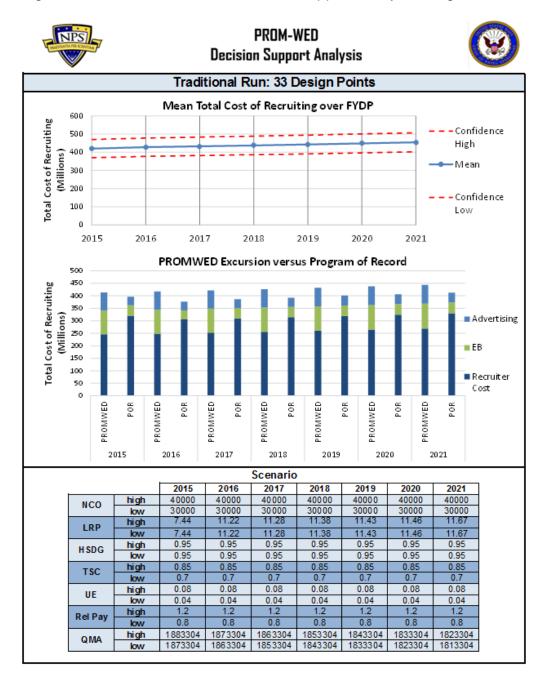


Figure 30. Traditional Run Decision Support Analysis, Page 1

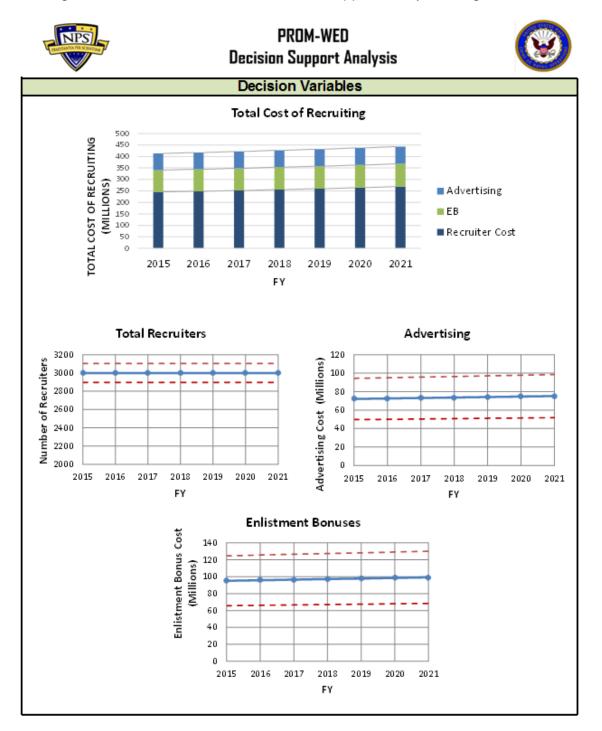


Figure 31. Traditional Run Decision Support Analysis, Page 2

The six graphs and one table make up the traditional run's decision support analysis. The purpose of each graph is now explained.

Starting in the top left, the "Mean Total Cost of Recruiting over FYDP" graph, also shown in Figure 32, shows the resulting mean total cost of recruiting for each FY.

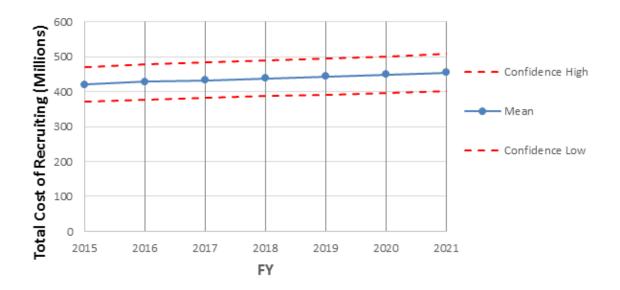


Figure 32. Graph 1: Mean Total Cost of Recruiting over FYDP

The mean for each FY is represented by the blue dots. The red dashed lines represent the 95 percent confidence interval for each mean. Where "n" is the number of sample points. For example, n = 33 for the 33-point NOLH design, and so forth. Here we are treating each observation as an equally likely sample of possible recruiting scenarios. The 95 percent confidence intervals for all graphs shown in the automatically generated decision support analysis are calculated as follows:

(1) First, the sample standard deviation is calculated:

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

The Microsoft Excel formula STDEV.S() is used in PROM-WED.

(2) Next, since each scenario is independent, and it is assumed that the sample mean is approximately normally distributed, the margin of error at 0.05 significance level is calculated:

margin of error
$$= z_{\alpha/2} \frac{s}{\sqrt{n}};$$

where: $\alpha = 0.05$ and
 $z_{\alpha/2}$ is the $100(1 - \alpha/2)$ percentile of a
standard normal random variable

The Microsoft Excel formula CONFIDENCE.NORM() is used in PROM-WED.

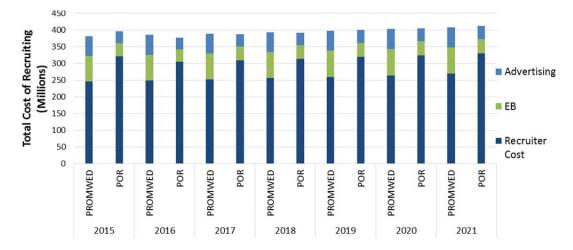
(3) Finally, the upper and lower confidence bounds are calculated:

$$\bar{x} \pm margin of error$$

The region between the two red dashed lines represents with 95 percent confidence the mean total cost of recruiting is somewhere within this range.

The second graph "PROM-WED Excursion versus Program of Record," also shown in Figure 33, compares the mean optimal allocation of recruiting resources that resulted from the PROM-WED excursion with the program of record.





The program of record (POR) is the resource allocation "recorded in the current Future Years Defense Program (FYDP) or as updated from the last FYDP by approved program documentation" (DAU, n.d.). Within the legacy PRO model the POR is fixed for each FY. PROM-WED only reports these fixed numbers (i.e., they are the same for each run and are not included in the DOE). Each bar of the stacked bar chart is divided into segments that represent the amount of resources allocated to each decision variable. A difference between a PROM-WED excursion and a POR conveys to an analyst that the Navy should consider allocating funds differently to optimize the allocation of recruiting resources. These insights support informed decisions such as adjusting the number of Sailors assigned to recruiting duty or modifying the amount of resources allocated to advertisements and enlistment bonuses. Education incentives were not included in the decision support analysis, but can be added if the Navy begins to allocate funds towards this resource again.

The scenario report, shown in Table 10, reports the high and low values of each market factor for this PROM-WED excursion.

		2015	2016	2017	2018	2019	2020	2021
NCO	high	40000	40000	40000	40000	40000	40000	40000
	low	30000	30000	30000	30000	30000	30000	30000
LRP	high	7.44	11.22	11.28	11.38	11.43	11.46	11.67
LKF	low	7.44	11.22	11.28	11.38	11.43	11.46	11.67
HSDG	high	0.95	0.95	0.95	0.95	0.95	0.95	0.95
пэре	low	0.95	0.95	0.95	0.95	0.95	0.95	0.95
TSC	high	0.85	0.85	0.85	0.85	0.85	0.85	0.85
	low	0.7	0.7	0.7	0.7	0.7	0.7	0.7
UE	high	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	low	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Rel Pay	high	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	low	0.8	0.8	0.8	0.8	0.8	0.8	0.8
QMA	high	1883304	1873304	1863304	1853304	1843304	1833304	1823304
	low	1873304	1863304	1853304	1843304	1833304	1823304	1813304

Table 10. PROM-WED Scenario Report

If the high and low values are equal, the market factor is fixed, such as NCO in the scenario shown in Table 10. If the market factor is tested over a range, the high and low values are not equal, such as assessing the effect of varying the percentage of high quality recruits (TSC) from 70 percent to 85 percent, also shown in Table 10.

The focus of the second page is on how the decision variables vary. The "Total Cost of Recruiting" stacked bar chart shown in Figure 34 indicates how much money is allocated to each recruiting resource over a seven FY span.

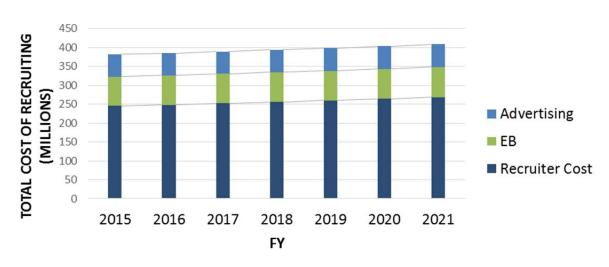


Figure 34. Graph 3: Total Cost of Recruiting

The following three graphs, shown in Figure 35, represent how deviations in controllable and uncontrollable factors affect the amount of resources allocated to each decision variable. The blue dots represent the mean for each decision variable over each FY, and the red dashed lines represent the 95 percent confidence interval about that mean.

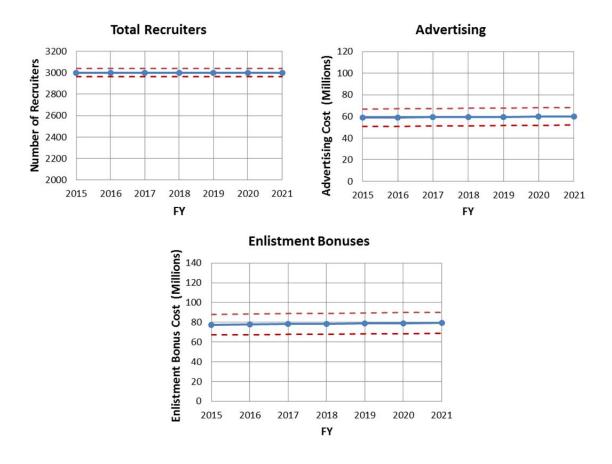


Figure 35. Graphs 4–6: Decision Variables

b. JMP Output

PROM-WED provides users with output results that are saved as an .xlsx file and can be further analyzed using any statistical software package. N1 analysts use JMP; hence PROM-WED's output is named "JMP output." JMP has modeling tools, such as partition trees and stepwise regression models, that are conducive for testing interactions between multiple variables while quantifying and visualizing how they affect the overall solution space.

PROM-WED's JMP output is color-coded by variable type, and is organized for ease of import into a data analysis package. A snap shot of the JMP output for one FY of a 33 design point PROM-WED excursion is shown in Figure 36.

 F
 G
 H
 I
 J

 Education Incentive
 Total Recruiters Cost
 NCO
 LRP
 HSDG

 0
 2938
 240.6322
 30875
 7.44
 0.99

 0
 2625
 214.9664
 37500
 7.44
 0.99

 0
 3406
 278.963
 37188
 7.44
 0.99

 0
 3500
 286.6619
 98125
 7.44
 0.99

 0
 3500
 286.6619
 38125
 7.44
 0.99

 2969
 243.1712
 34063
 7.44
 0.95

 230.3942
 31563
 7.44
 0.95

 A
 B
 C

 Run #
 FY
 Total Cost of Rec

 1
 2015
 403.8507

 2
 2015
 402.814

 3
 2015
 363.1657

 4
 2015
 510.0452

 6
 2015
 662.9863

 6
 2015
 303.9277

 7
 2015
 452.7505

 8
 2015
 294.6683

 9
 2015
 298.6863
 D EB 70.625 59.688
 OG
 TSC I-IIIA
 Unemployn

 19
 0.7
 4.4

 19
 0.7
 8
 QMA 1823929 1798929 Advertising 85.1535 120.457 Relative F 1.075 0.975 6.9087 69.844 0.7 .1875 1845804 157.0373 239.4061 58.906 72.969 0.7 0.8375 1861429 1814554 0.85 2813 3469 3438 2719 4.0595 60.469 1.0125 1808304 71.406 61.25 62.813 284.1229 281.5839 7.44 0.99 89.7816 0.8 85517 0.7 5.9 6.8 0.84 9 2015 299.6583 222.6953 30000 7.44 0.97 0.7 1.0375 1877054
 10
 2015

 11
 2015

 12
 2015

 13
 2015

 14
 2015

 15
 2015

 16
 2015

 17
 2015

 19
 2015

 21
 2015

 22
 2015

 23
 2015
 20.656 6.0992 42.3748 68.281 56.563 2781 3250 227.7733 266.186 258.4871 6.6 4.9 0.875 324.1503 30938 7.44 0.98 0.7 188017
 30550
 7.44
 0.90

 31250
 7.44
 0.97

 34688
 7.44
 0.96

 39688
 7.44
 0.96
 336.2882 387.5209 0.7 181767 13 79.219 3156 6.9 0.7 0.8625 182705 2904.1699 374.174 497.6156 347.6317 220.1563 235.4723 273.8849 14 2618.4486 58,125 2688 0.7 4.6 0.9125 1883304 5 7.44 3 7.44 0.96 1.1125 0.9375 15 16 62.1987 161.2907 69.063 2875 3344 39375 6.4 0.7 0.7 55 77.056 67.5 9.0266 253.4091 562 7.44 0.98 0.7 0.5 1.1 1830179 29.0347 12.0682 10.8643 171.8391 18 349.6849 245.7102 35000 7.44 0.97 0.7 1833304 35000 7.44 0.97 33125 7.44 0.95 32500 7.44 0.95 32813 7.44 0.98 64.375 75.313 65.156 334.7533 370.0413 19 20 3063 250.8701 0.7 7.6 0.925 1842679 276.424 212.4574 3375 0.7 1.025 1867679 456.8928 07 6.3 0.8125 1820804 21 22 23 9.1792 5.9053 225.3926 297.4717 323.6255 568.4716 76.094 62.031 74.531 2500 3031 3188
 31875
 7.44
 0.97

 35938
 7.44
 0.99

 38438
 7.44
 0.99
 1.1625 1.15 0.9875 1805179 1852054 1858304 204.7585 248.2492 0.7 24 261.108 43
 24
 23
 2015

 25
 24
 2015

 26
 25
 2015

 27
 26
 2015

 28
 27
 2015

 29
 28
 2015

 30
 29
 2015

 31
 30
 2015

 32
 314
 2015
 26.4097 63.594 2100.6177 73.75 110.1519 72.188 2531 2563 3281
 36030
 7.44
 0.35

 36250
 7.44
 0.96

 37813
 7.44
 0.97

 40000
 7.44
 0.97
 207 2975 209 9184 304.7412 6.1 1811429 2391.726 0.825 180205 268.725 0.7 0.9625 1789554 380.9688 43.1628 66.719 3219 263.647 39063 7.44 0.96 0.7 5.4 1786429 494.1179 322.9417 356.2942 183.0056 26.7874 0.6333 2750 2844 3313
 33003
 7.44
 0.90

 38750
 7.44
 0.98

 35313
 7.44
 0.98

 30313
 7.44
 0.98
 78.438 55.781 225.2343 0.95 184892 183955 232.9333 271.3459 0.7 76.875 0.7 1.0875 1783304 32 **31** 2015 33 **32** 2015 34 **33** 2015 346.3979 311.9011 412.3618
 17.0718
 65.938

 6.9257
 80

 109.5665
 57.344
 30625 7.44 33438 7.44 34375 7.44 0.98 3125 2656 2906 255.9481 217.5354 0.8875 238.0113 1836429

Figure 36. JMP Output for a 33 Design Point

Blue represents the output: Total Cost of Recruiting, green represents the decision variables, orange represents policy factors, and red represents the environmental factors.

This thesis uses JMP Pro Version 12 to analyze PROM-WED data using six primary techniques: (1) oneway analysis graphs, (2) distributions and descriptive statistics, (3) partition trees, (4) stepwise regression models, (5) scatterplot matrices, and (6) contour plots (JMP Pro, 2015). The purpose of this section is to explain the principal techniques that are used in the analysis section. With many of these techniques additional analysis could be done. The analysis provided in this research is illustrative of what analysts can do with PROM-WED output.

(1) Oneway Analysis Graphs

A oneway analysis graph is used to gain a quantifiable understanding of the spread of the total cost of recruiting data over each FY. The setup and structure of this graph is shown in Figure 37.

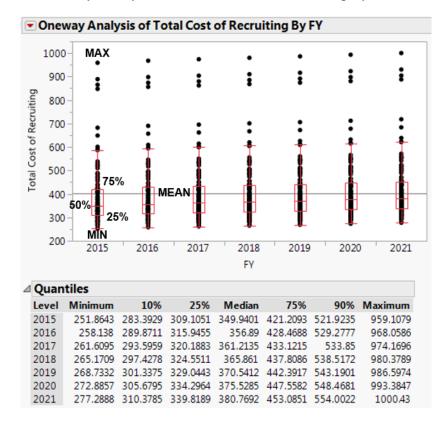


Figure 37. Oneway Analysis of Total Cost of Recruiting by FY Structure

The boxplots that overlay the data represent the information presented in the "Quantiles" table. From Figure 37, it is evident that more than 50 percent of the data (i.e., the median) is less than the grand mean. The grand mean is represented by the horizontal line labeled "mean," and the median is represented by the "50%" label. The median is a useful estimator that provides safety against outliers, whereas the mean is highly influenced by extreme values, both high and low.

(2) Distributions and Descriptive Statistics

Histograms provide insight regarding the nature of the output data. For example, Figure 38 shows that the total cost of recruiting is highly skewed to the right. The long tail indicates that there are some particularly large outliers, but the majority of the data does not follow this trend.

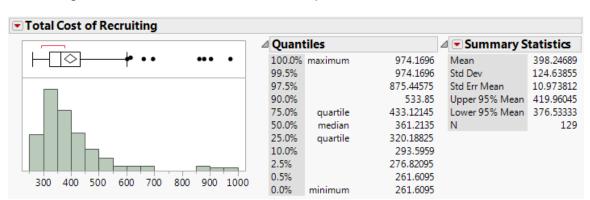


Figure 38. Distribution and Descriptive Statistics Structure

(3) Partition Tree

The setup and structure for a partition tree is shown in Figure 39.

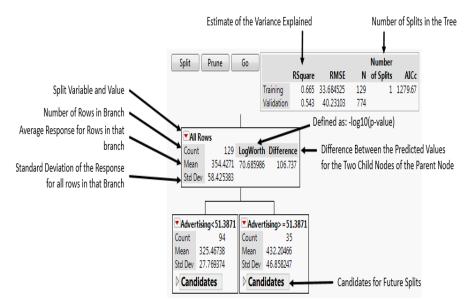


Figure 39. JMP Partition Tree Structure

Adapted from Borozny, 2015, p. 37; Lane, n.d.

A story can be told from interpreting a partition tree. For instance, the tree shown in Figure 39 conveys the following message:

The mean total cost of recruiting will be approximately \$354 million. Since advertising is the first child of the parent node, advertising is the dominant decision variable, where 66.5 percent of the variance for the total cost of recruiting can be explained. If the cost of advertising remains below \$51.4 million, then the average cost of recruiting is approximately \$325 million. If the cost of advertising equals to or exceeds \$51.4 million, then the average cost of recruiting increases to \$432 million.

(4) Stepwise Regression Model

Stepwise regression can be used to formulate a prediction model for total cost of recruiting, as shown in Figure 40.

	Beta Estimates					
	Parameter Estimates					
	Term	Estimate	Std Error	t Ratio	Prob> t	
ſ	Intercept	150.98005	70.71931	2.13	0.0348*	
	NCO	0.025536	0.001535	16.64	<.0001*	
Regression	Unemployment	-24.59368	3.836157	-6.41	<.0001*	
Terms	Relative Pay	-550.348	38.3648	-14.35	<.0001*	
icinis	(NCO-35000.1)*(Relative Pay-1)	-0.127001	0.015311	-8.29	<.0001*	
	(NCO-35000.1)*(NCO-35000.1)	3.0499e-6	6.205e-7	4.92	<.0001*	
	(Relative Pay-1)*(Relative Pay-1)	1882.3763	384.6306	4.89	<.0001*	

Beta Estimates

Figure 40. Stepwise Regression Structure

The beta estimates and regression terms shown in Figure 40 are used to formulate the prediction model shown in Figure 41.

Figure 41. Prediction Model for Total Cost of Recruiting Fit Using Stepwise Regression

Prediction Expression

```
150.980052850998
```

```
+ 0.02553596931337 * NCO
```

- + -24.593679044673 * Unemployment
- + -550.34801858165 * Relative Pay
- + (NCO 35000.0620155039)* ((Relative Pay 1)* -0.1270005027034)
- + (NCO 35000.0620155039)* ((NCO 35000.0620155039) * 0.00000304992539)

```
+ (Relative Pay - 1)* ((Relative Pay - 1)* 1882.37625427676)
```

Actual by predicted plots, as shown in Figure 42, demonstrate the relationship between the actual data and the model fit using stepwise regression. In this case, the closer the points are to the solid red line the better the fit.

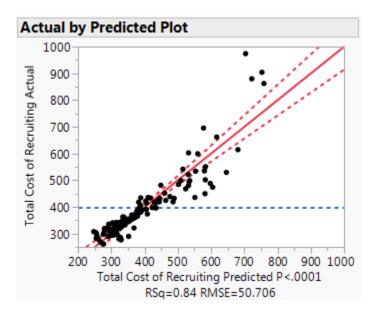
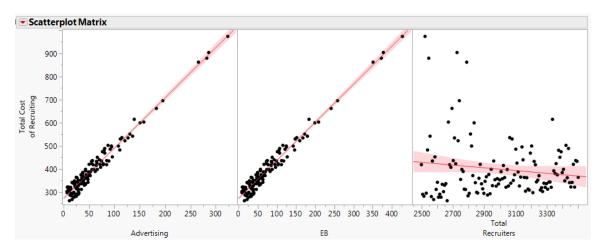
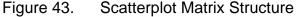


Figure 42. Actual by Predicted Plot.

(5) Scatterplot Matrices

Each panel of the scatterplot matrix in Figure 43 shows the relationship between a decision variable, on the x-axis, and the total cost of recruiting, on the y-axis.





The dark red line within the shaded red region indicates a trend line fit in JMP. From these scatterplot matrices, trends can be deduced to help analysts further understand the relationships amongst the model's variables. For example, both advertising and EB show a distinct, upward linear trend in relation to the total cost of recruiting. The narrow confidence bands around the trend line also indicate this is a strong relationship. Whereas, the total number of recruiters has only a minor, downward trend. The wider confidence interval around the trend line for this plot indicates that the total number of recruiters has minimal effect on the total cost of recruiting for this scenario.

(6) Contour Plots

Contour plots provide insights similar to the "capture the flag" example previously shown in Figure 22, where the multi-level full factorial DOE provides a detailed understanding of the solution space. The contour plot in Figure 44 shows the relation between relative pay and accession mission on the total cost of recruiting. Note that other factors are changing too, so it is important to look for broad trends, not local features.

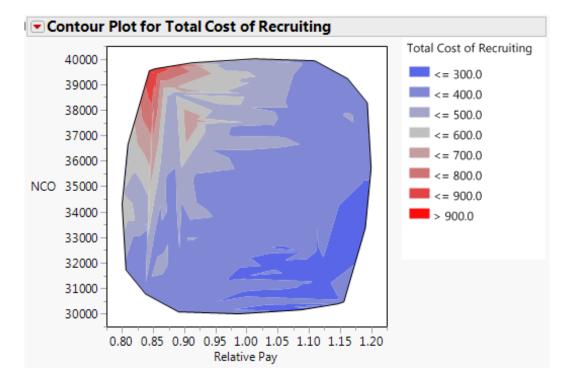


Figure 44. Contour Plot Structure

The color variations in Figure 44 represent the total cost of recruiting at different combinations of relative pay and new accession mission values. The diagonal nature of the plot indicates there is an interaction between relative pay and the new accession mission. To minimize the total cost of recruiting, it is recommended that the Navy stays within the dark blue regions if the higher relative pay is feasible.

c. Building PROM-WED: Collaboration with Future Users

To ensure the practicality and future usability of this research, analysts at N1 played a critical role in the creation of the PROM-WED tool, specifically in regards to the GUI development and the decision support capabilities. A future PROM-WED user had hands-on time with the tool to test its limitations and

identify potential glitches. Through this meeting, we identified problems with the save scenario capability and identified sources of potential confusion that needed clarification and were subsequently addressed within the PROM-WED User Manual. In addition to the GUI, N1 analysts were involved in the development of PROM-WED's decision support capability. For instance, the JMP output color-coding and the scenario report were added to the automatically generated decision support capability based on feedback from N1 analysts.

As with any new tool, it may take time for N1 analysts to become accustomed to using PROM-WED. For example, it was requested that a graph be added to the automatically generated decision support capability that displayed how unemployment rate effects the total cost of recruiting over each FY. An example of this graph is shown in Figure 45. The parameter inputs for the PROM-WED excursions shown in Figures 45 and 46 can be found in Appendix D.

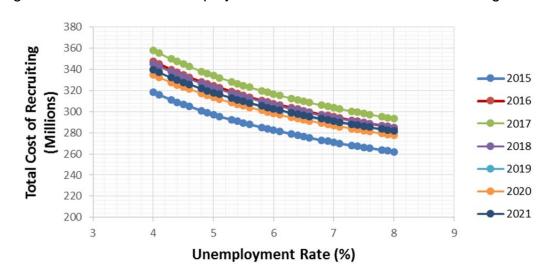
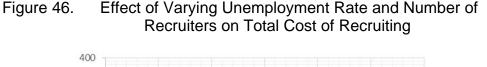
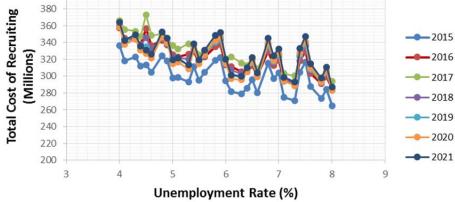


Figure 45. Effect of Unemployment Rate on Total Cost of Recruiting

As expected, when the unemployment rate is low, the cost of recruiting is high, and as unemployment rate increases the cost of recruiting decreases. However, PROM-WED is capable of testing uncertainties in multiple variables, not just one. When more than one variable is tested over a range, the graph becomes difficult to interpret. For example, Figure 46 is a PROM-WED excursion with the same input parameters as the PROM-WED excursion shown in Figure 45 except the number of recruiters is bounded from 2,500 to 3,500, instead of fixed at 3,913 as shown in Figure 45.





From Figure 46, it is evident that bounding the number of recruiters does affect the total cost of recruiting. However, it is difficult to discern any valuable insights from Figure 46 regarding the interactions that are occurring between the varied number of recruiters and the unemployment rate on the total cost of recruiting. This example only varied two variables, whereas excursions that are explored in the next section vary up to six variables.

Examples such as this one demonstrate that through the implementation of DOE techniques, PROM-WED delivers results that provide valuable insights into the optimal allocation of recruiting resources. However, this added capability challenges the legacy analysis methods used to study legacy PRO model outputs.

IV. ANALYSIS

Through two test case examples, this chapter showcases PROM-WED's ability to deliver comprehensive insights into the optimal allocation of recruiting resources. The chapter begins with the introduction of the two test case examples, referred to as Test Case 1 and Test Case 2. These examples are first analyzed through PROM-WED's automatically generated decision support capabilities, and further explored using an array of statistical modeling and graphing methods in JMP. Finally, a modified version of Test Case 1 is used to compare the number of runs required for a full factorial DOE to the NOLH designs used in PROM-WED.

A. TEST CASES

To demonstrate PROM-WED's capabilities, N1 formulated three separate scenarios to model best case, worst case, and most likely situations for Navy recruiting. These scenarios are found in Appendix E. Rather than running three separate scenarios, PROM-WED can test this broad spectrum of possibilities and uncertainties using a single data farming run.

Test Case 1 explores uncertainties in economically driven market factors (i.e., relative pay and unemployment rate). Test Case 2 adds two additional degrees of uncertainty to Test Case 1 in the form of policy factor changes (i.e., QMA and recruit quality). All market factors not listed in the tables remain at their default values from the legacy PRO model. The scenario reports for each run are available in Appendix D.

a. Test Case 1

Test Case 1 covers a broad spectrum of economic uncertainties that represent best case, worst case, and most likely scenarios for Navy recruiting. For example, a low unemployment rate, relative pay favoring the civilian sector, and a high recruiting accession mission are challenging conditions for Navy recruiting. On the other hand, a high unemployment rate, relative pay favoring the military, and a low recruiting accession mission would be favorable conditions for Navy recruiting. The input values for Test Case 1 are shown in Table 11 and can be used to answer a question such as:

What is the optimal allocation of recruiting resources that is robust to a broad range of economic uncertainties?

Variable Type	Variable Name	Value Low	Value High	
Decision Variable	Recruiters	2,500 recruiters	3,500 recruiters	
Market Factor	Unemployment Rate	4.0%	8.0%	
Market Factor	Relative Pay	0.80	1.20	
Policy Factor	Recruiting Mission (NCO)	30,000 recruits	40,000 recruits	

 Table 11.
 Test Case 1 Input Variables

For additional scenario details, refer to Appendix D.

b. Test Case 2

Test Case 2 maintains the foundation of Test Case 1, but adds the effects of varying two policy factors: (1) percentage of high quality recruits, and (2) qualified military available. Test Case 2's input variables are shown in Tables 12 and 13, and can be used to answer a question such as:

What is the optimal allocation of recruiting resources if the Navy desires to increase the percentage of high quality recruits from 70 percent to 85 percent? Due to uncertainties in the current fiscal environment, the unemployment rate may fluctuate between 4 to 8 percent, and the ratio of relative pay may vary between 0.8 and 1.2. In addition, since marijuana has been legalized for recreational use in many states nationwide, drug-use amongst 18–24 year-olds is expected to increase. An increase in drug-use amongst this age group means fewer young adults qualify for military service. Test Case 2 models the effect of an annual decrease of 10,000 qualified military available due to pre-service drug-use.

Variable Type Variable Name		Value Low	Value High
Decision Variable	Production Recruiters	2,500 recruiters	3,500 recruiters
Market Factor	Unemployment Rate (UE)	4.0%	8.0%
Market Factor	Percentage of High Quality Recruits (TSC I-III)	70%	85%
Market Factor	Relative Pay	0.8	1.2
Market Factor	Qualified Military Available (QMA)	*See Table 13	
Policy Factor	Recruiting Mission (NCO)	30,000 recruits	40,000 recruits

Table 12.Test Case 2 Input Variables

Since Test Case 2 models the cumulative effects that the legalization of marijuana may have on the nation's QMA, the input values for QMA will decrease by 10,000 each FY. The QMA input values for Test Case 2 are shown in Table 13.

FY	QMA Value Low	QMA Value High
2015	1,873,304	1,883,304
2016	1,863,304	1,873,304
2017	1,853,304	1,863,304
2018	1,843,304	1,853,304
2019	1,833,304	1,843,304
2020	1,823,304	1,833,304
2021	1,813,304	1,823,304

Table 13.Traditional Run 2 QMA Input Values

For more information regarding Test Case 2 parameter inputs, refer to Appendix D.

B. DECISION SUPPORT ANALYSIS

As explained in Chapter III, PROM-WED automatically generates a selection of graphs to provide decision-makers with an "at-a-glance" understanding of the solution space. The 33-point design grows a sufficient

amount of data for basic statistical analysis in under two minutes. Since the purpose of the decision support analysis is to provide a quick understanding of the solution space, only the 33-point NOLH design is analyzed in this section. This type of analysis would be appropriate for testing excursions during a time constrained meeting, working group, or whenever basic analysis needs to be generated quickly. The 129-point NOLH grows more data, requiring a longer run time and more time is needed for adequate analysis. The 129-point NOLH is used in the JMP analysis section.

1. Test Case 1

Some major insights that are gained from Test Case 1's automatically generated decision support capability are now discussed. Figure 47 demonstrates that in an uncertain economic environment, the mean total cost of recruiting in FY 2017 will be within \$350 million to \$450 million, with 95 percent confidence.

Figure 47. Test Case 1: Mean Total Cost of Recruiting over FYDP

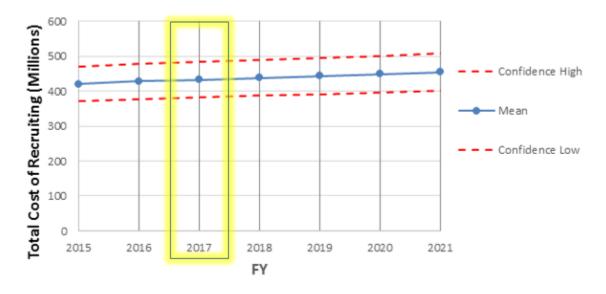
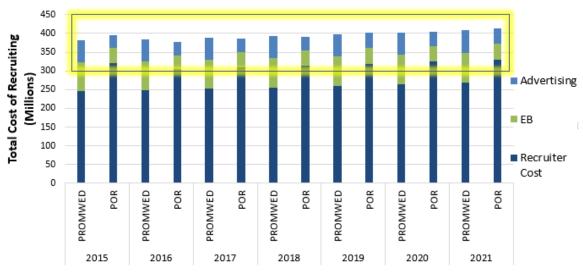


Figure 48 indicates that on average, the optimal cost of recruiting for each FY complements the program of record (POR) budget estimate.



The graph shown in Figure 48 can also inform decisions to redistribute funds to optimize the allocation of resources to advertisements, enlistment bonuses, and recruiters. For example, in the same graph, now labeled Figure 49, informed recommendations can be made to distribute resources differently in order to optimize the allocation of recruiting resources.

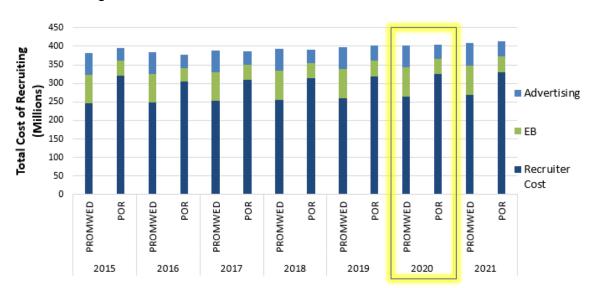
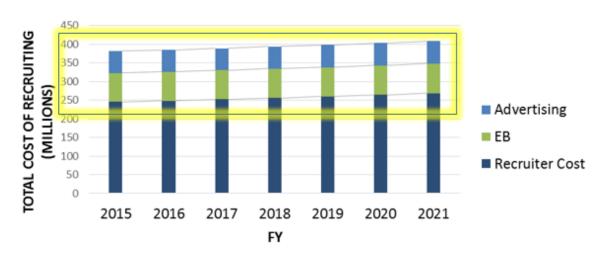


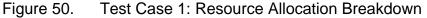
Figure 49. Test Case 1: PROM-WED versus POR

Test Case 1: PROM-WED Excursion versus POR

Dependent upon FY, if the dark blue bar is higher for POR than PROM-WED, this indicates that in order to optimize the allocation of recruiting resources, less resources need to be allocated to recruiters. Less funding allocated to recruiters means less recruiters are required in the field. The same convention goes for enlistment bonuses and advertisements. For example, in FY 2020 less funds should be allocated to recruiting and more funds should be allocated to enlistment bonuses and advertisements.

Figure 50 shows that the optimal allocation of recruiting resources appears to sustain a consistent trend amongst the seven FYs with only a minor upward trend, most likely due to inflation rates.





Insights gained through Figures 48 and 50 indicate there is evidence to believe that the total cost of recruiting is robust to uncertainties in the economic environment. However, to optimize the allocation of resources, more resources need to be allocated to enlistment bonuses and advertisements, as shown previously in Figure 49.

Figure 51 indicates that, with 95 percent confidence, the optimal allocation of resources to advertising over the seven FY span is consistently maintained within the range of approximately \$40 million to \$80 million.

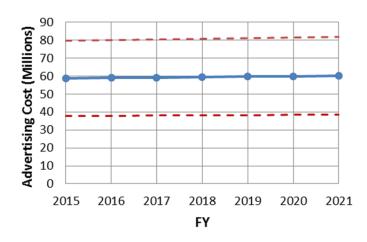
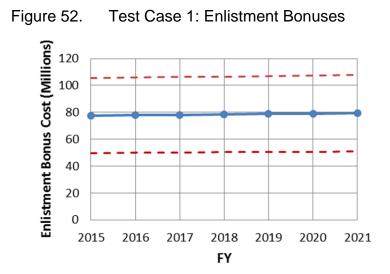


Figure 51. Test Case 1: Advertising

Similar to the insights gained from Figure 51, Figure 52 demonstrates that with 95 percent confidence, the optimal allocation of resources to enlistment bonuses over the seven FY span consistently maintains a range of \$50 million to \$110 million.



2. Test Case 2

The effects of a shrinking QMA pool and an increased requirement for recruit quality is analyzed through the comparison of Test Case 1 and Test Case 2.

From Figure 53, there is evidence to believe that the Navy can expect the total cost of recruiting to increase by approximately \$50 million as the need for high quality recruits increases, and the QMA pool shrinks. Without these policy influences, the 95 percent confidence interval increased from \$350 million to \$450 million in Test Case 1, to approximately \$400 million to \$500 million in Test Case 2.

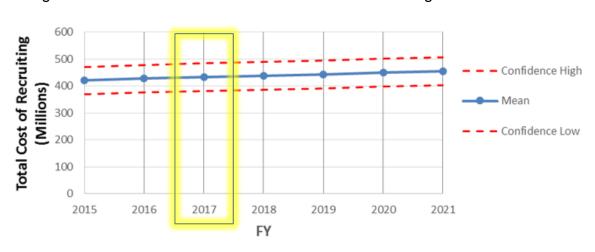


Figure 53. Test Case 2: Mean Total Cost of Recruiting over FYDP

Figure 54 indicates that the total cost of recruiting is expected to exceed the program of record for every FY.

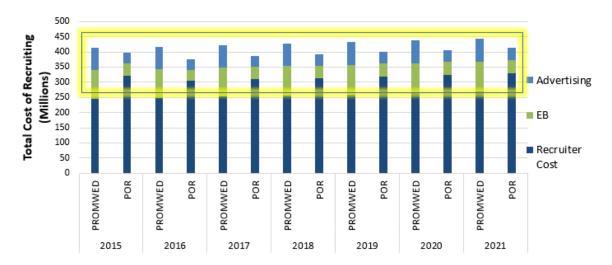


Figure 54. Test Case 2: PROM-WED Excursion versus POR

To optimize the allocation of recruiting resources, there appears to be a consistent trend amongst all seven FYs that an excess of resources was allocated to recruiters in the POR, while more resources should be allocated to advertisements and enlistment bonuses instead.

Due to the addition of QMA uncertainties and recruit quality policy changes, Figure 55 indicates that the average cost of recruiting is expected to increase by approximately \$50 million over the seven FY span. This is a noticeable increase over the trend previously shown for Test Case 1 in Figure 50.

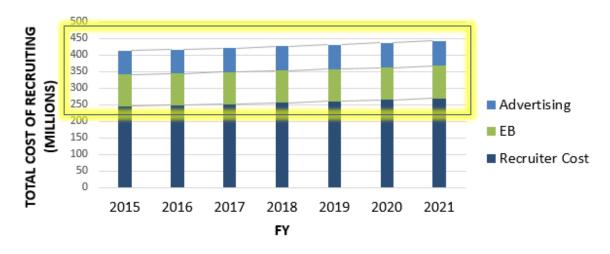
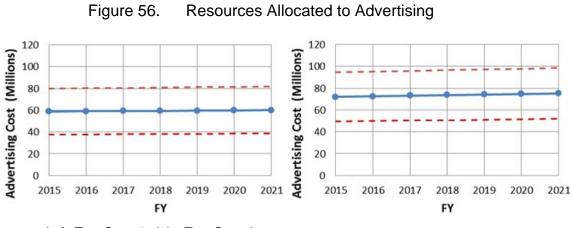


Figure 55. Test Case 2: Resource Allocation Breakdown

Figures 56 and 57 juxtapose results for advertisement and enlistment bonus resource allocations for Test Case 1 and Test Case 2.



Left: Test Case 1, right: Test Case 2.

Figure 56 indicates that the cost of advertising will increase by an average of approximately \$10 million each FY.



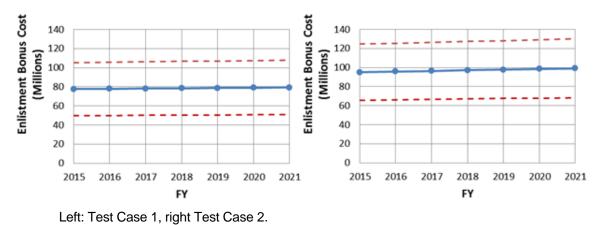


Figure 57 indicates a similar trend for enlistment bonuses. These graphs show that an additional \$20 million will be required for enlistment bonuses each FY due to the addition of QMA uncertainties and proposed recruit quality changes.

C. GRAPHICAL AND STATISTICAL ANALYSIS IN JMP

Valuable insights can be found through analyzing variable interactions and uncertainties that shape the robust solution space. However, analyzing and visualizing variable interactions in Microsoft Excel is difficult due to the software's limited statistical capability. Analysts will need to use a statistical software package to take full advantage of the data grown by PROM-WED. Test Case 1 and Test Case 2 are now analyzed using JMP.

1. Test Case 1

To gain an initial understanding of the data, Figure 58 shows the spread of data and provides quantile metrics for each FY. From Figure 58, it is evident that over 50 percent of the data, indicated by the median, generated for each FY is below the grand mean total cost of recruiting for each FY.

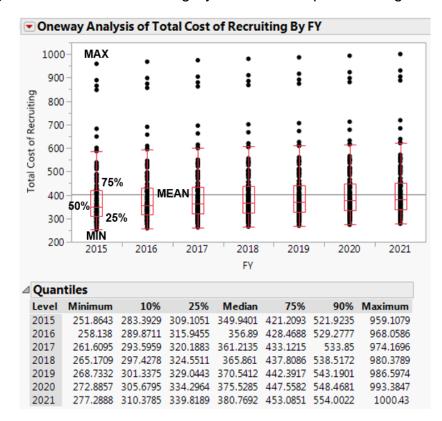


Figure 58. Total Recruiting By FY with Interguartile Ranges

The outliers in Figure 58, highlighted below in Figure 59, are worth examining further to determine if there is a common cause for the four unusual data points. Using JMP, the highlighted sixteen data points are lassoed (i.e., selected) to reveal that the 78th, 80th, 88th, and 96th runs for each scenario caused these results over each FY. The run numbers represent four of the 129 different scenarios built using PROM-WED's 129-point NOLH DOE. Since each FY uses the same NOLH DOE, the 80th run for each FY of Test Case 1 is tested over the same input market factors and number of recruiters. The same convention applies for the 78th, 88th, and 96th runs as well.

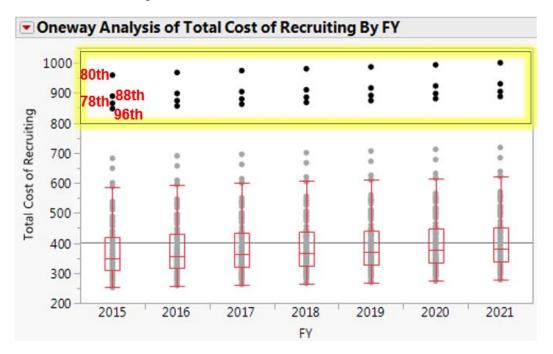


Figure 59. Outliers for Each FY

The upward trend occurs due to yearly changes, such as inflation rates, elasticities, or input values from the legacy PRO model. The input variables for each run highlighted in Figure 59 are shown in Table 14.

 Table 14.
 Test Case 1 Input Variables for Output Outliers

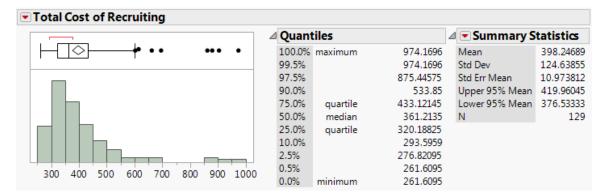
	Run #					
	78	80	88	96		
Recruiters	2547	2523	2727	2789		
NCO	39531	39688	39453	39609		
UE	7.0	5.9	5.1	5.1		
Relative Pay	0.84375	0.878125	0.85	0.853125		

The most extreme total cost of recruiting outlier, resulting from the 80th run, tested an excursion where the Navy had a very low number of recruiters in the field (just over 2,500 recruiters), the new accession mission was extremely high (almost at 40,000 new recruits), unemployment rate was mediocre, and the relative pay favored the civilian sector. The other three runs also showed similar

trends where high accession missions, with a low number of recruiters in the field, and relative pay highly favoring the civilian sector resulted in unusually high expected recruiting costs. Identifying these costly outliers can help N1 analysts make informed recommendations to avoid situations like the 80th run by preemptively increasing the number of recruiters in the field.

To gain additional situational awareness of the data, the distributions and descriptive statistics for each decision variable are explored. Figure 60 shows the histogram of the distribution for total cost of recruiting over one FY of the PROM-WED excursion. Histogram and descriptive statistics for resourcing to advertisements and enlistment bonuses can be found in Appendix F.

Figure 60.	Histogram and Descriptive Statistics for Total Cost of
	Recruiting Distribution for FY 2017



The histogram indicates that the distribution is highly skewed to the right. As well, the four data points that appear in the far right side of the histogram again represent runs 78, 80, 88, and 96.

Partition trees were used to understand how variable interactions and economic uncertainties affected the solution space. The partition trees in Figures 61 and 62 take into consideration the influence of each decision variable on the total cost of recruiting. Figure 61 shows the first split of the partition tree for total cost of recruiting, specifically for FY 2017.

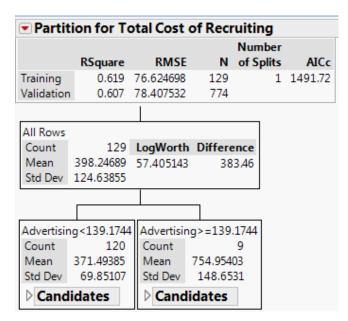


Figure 61. First Split of Total Cost of Recruiting Partition Tree

Figure 61 indicates that resourcing to advertising is the most influential predictor of the total cost of recruiting. 61.9 percent of the variance for the total cost of recruiting can be explained based on the first split of the partition tree. When less than \$139 million is allocated to advertising, then the mean total cost of recruiting will be approximately \$371 million. If more than \$139 million is allocated to advertising will increase to almost \$755 million.

Figure 62 shows the next split of the partition tree shown in Figure 61.

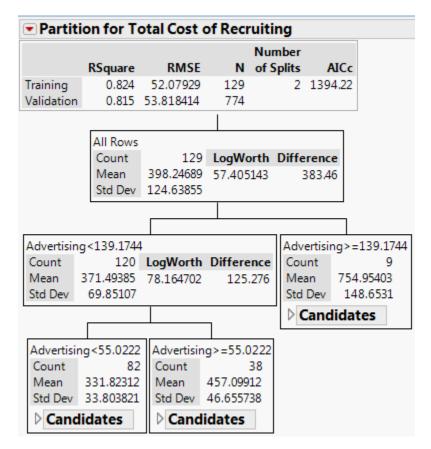


Figure 62. Second Split of Total Cost of Recruiting Partition Tree

The second split of the partition tree indicates that resourcing to advertising is identified again as the dominant predictor of the total cost of recruiting. Based on this split, over 80 percent of variance in the total cost of recruiting is explained. Repeated splitting of the same factor, in this case resources allocated to advertising, indicates regression may be a more informative analysis technique.

Next, a partition tree is used to understand which market factors most influence advertising. Figure 63 shows the parent and first child node of the partition tree for advertising.

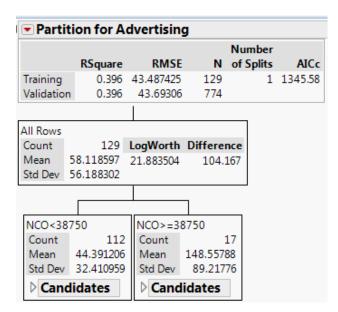


Figure 63. Parent and First Child Node of Partition Tree for Advertising

The partition tree in Figure 63 indicates that the recruiting accession mission is the most influential factor on the cost of advertising. The relatively small R-squared value indicates that a single split on accession mission explains only 39.6 percent of variance. In particular, if the accession mission is below 38,750 new recruits, the mean resourcing towards advertising is approximately \$44.4 million. If the accession mission exceeds 38,750 new recruits, then the mean resourcing to advertising increases by over \$100 million, to \$148.6 million.

Following seven additional splits, as shown in Figure 64, it is evident that the resourcing of funds to advertising is influenced by many factors, to include: the new accession mission, relative pay, and to a small extent, the unemployment rate. Since it took seven splits to surpass the 80 percent Rsquared threshold, it is evident that these three factors influence the resourcing of funds to advertising, but none of them particularly dominate.

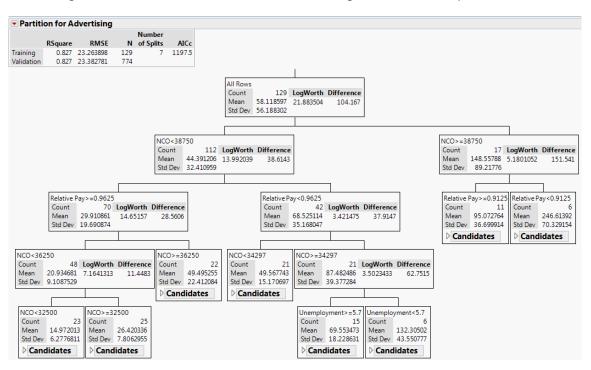


Figure 64. Partition Tree for Advertising After Seven Splits

Stepwise regression is another method used to gain insights into how variables influence the solution space. Using stepwise regression with some manual judgement, the parameter estimates shown in Figure 65 are used to formulate the prediction model for the total cost of recruiting, shown in Figure 66.

Figure 65. Stepwise Regression for Total Cost of Recruiting

Parameter Estimates							
Term	Estimate	Std Error	t Ratio	Prob> t			
Intercept	150.98005	70.71931	2.13	0.0348*			
NCO	0.025536	0.001535	16.64	<.0001*			
Unemployment	-24.59368	3.836157	-6.41	<.0001*			
Relative Pay	-550.348	38.3648	-14.35	<.0001*			
(NCO-35000.1)*(Relative Pay-1)	-0.127001	0.015311	-8.29	<.0001*			
(NCO-35000.1)*(NCO-35000.1)	3.0499e-6	6.205e-7	4.92	<.0001*			
(Relative Pay-1)*(Relative Pay-1)	1882.3763	384.6306	4.89	<.0001*			

The stepwise regression model exhibits how the NOLH DOE allows for non-linear relationships and interactions.

Figure 66. Test Case 1, Prediction model for Total Cost of Recruiting

```
Prediction Expression

150.980052850998

+ 0.02553596931337 * NCO

+ -24.593679044673 * Unemployment

+ -550.34801858165 * Relative Pay

+ (NCO - 35000.0620155039) * ((Relative Pay - 1) * -0.1270005027034)

+ (NCO - 35000.0620155039) * ((NCO - 35000.0620155039) * 0.00000304992539)

+ (Relative Pay - 1) * ((Relative Pay - 1) * 1882.37625427676)
```

The prediction model for total cost of recruiting indicates that the new accession mission and relative pay interact to effect the total cost of recruiting. The new accession mission and relative pay both exhibit a non-linear behavior as evidence by their polynomial to degree two interactions. This relationship can also be visualized in the prediction profiler shown in Figure 67.

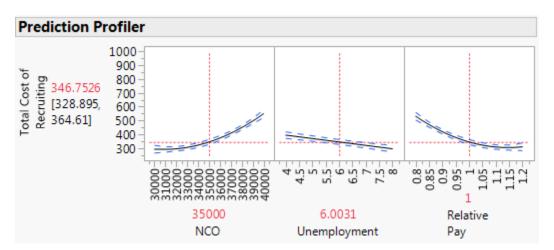


Figure 67. Prediction Profiler for Varying Factors in Test Case 1

The prediction profiles for the new accession mission and relative pay shown in Figure 67 demonstrate their quadratic nature.

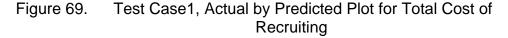
Next, the summary of fit for the regression model shown is shown in Figure 68.

Figure 68. Summary of Fit for Total Cost of Recruiting Prediction Model

Summary of Fit				
RSquare	0.842252			
RSquare Adj	0.834494			
Root Mean Square Error	50.70598			
Mean of Response	398.2469			
Observations (or Sum Wgts)	129			

This model explains over 84 percent of the variance of the total cost of recruiting for FY 2017.

To visualize a comparison of this model to actual FY 2017 data, the actual versus predicted plot is shown in Figure 69.



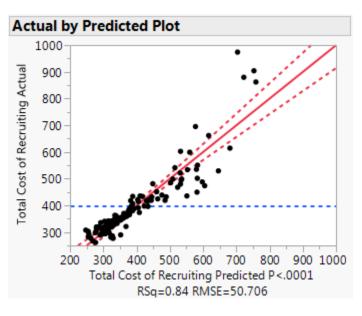


Figure 70 highlights the outlying points. Once again, runs 78, 80, 88 and 96 appear to be outliers.

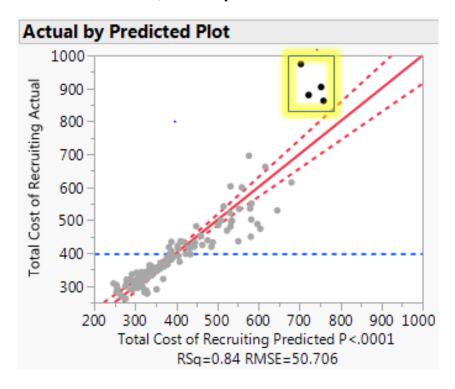


Figure 70. Test Case1, Actual by Predicted Plot with Outliers

Since the new accession mission, unemployment rate, and relative pay drive advertising resourcing, six scatterplot matrices, shown in Figure 71, help analysts visualize trends amongst these factors against the total cost of recruiting and the resourcing of funds to advertising. As before, we plot the response (in this case, total cost of recruiting and advertising costs) against new accession mission, unemployment rate, and relative pay. The values for the new accession mission, unemployment rate, and relative pay come from the NOLH DOE. Other factors such as allocated funds to EB and the number of recruiters in the field, are also changing (EB is being optimized, while number of recruiters comes from the NOLH DOE). Therefore, the trends in these scatterplot matrices should be considered through the lens of a broad picture, not localized trends.

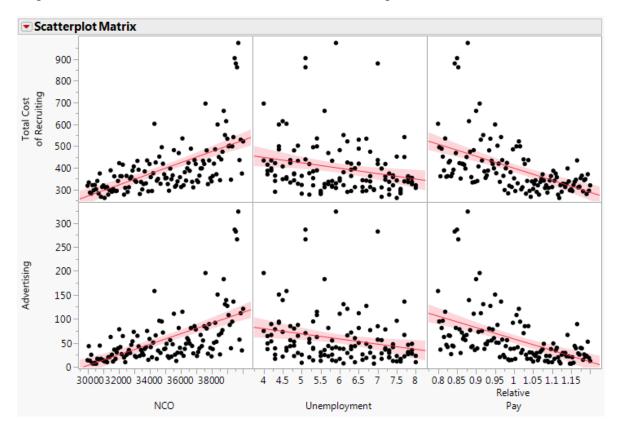


Figure 71. Economic Factor Trends on Recruiting Resource Allocation

The two scatterplot matrices for NCO versus advertising and NCO versus total cost of recruiting both indicate an upward trend, where a higher accession mission correlates with more resources allocated toward advertising and a higher total cost of recruiting. Both of the unemployment rate graphs show minor signs of a downward trend indicating that the cost of recruiting and the allocation of resources to advertising decreases, as the unemployment rate increases. Lastly, the relative pay versus advertising and relative pay versus total cost of recruiting graphs also indicate a trend. As the relative pay begins to increase, meaning wages favor the military over the civilian sector, resourcing towards advertising begins to decrease and the total cost of recruiting also decreases.

The four outlying points from runs 78, 80, 88 and 96 are present in these scatterplots as well. Figure 72 highlights results from these four runs. Once again, they appear to be outliers within each scatterplot.

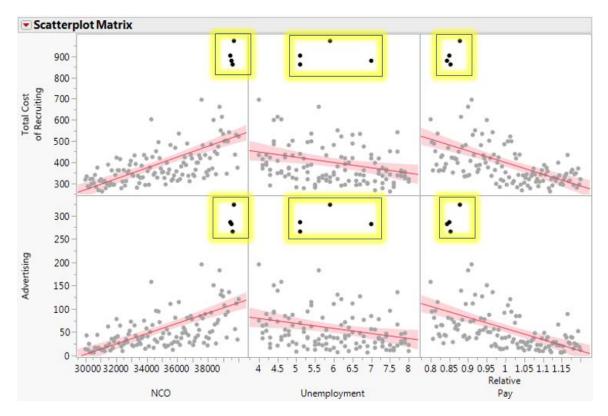
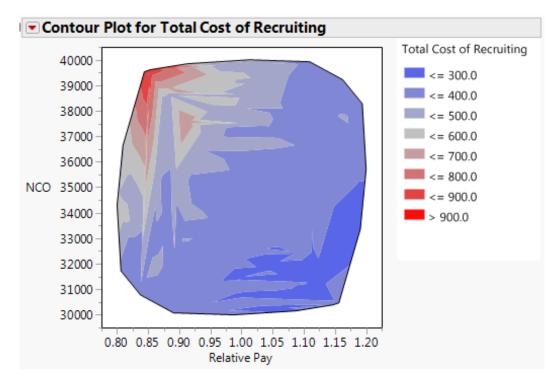


Figure 72. Economic Factor Trends on Recruiting Resource Allocation with Outliers

Variable interactions can also be shown in a three-dimensional manner using contour plots. The contour plot in Figure 73 represents the interaction between relative pay and accession mission on the total cost of recruiting.

Figure 73. Three-Dimensional Representation of Relative Pay and NCO Effects on the Total Cost of Recruiting



The diagonal color transition indicates the presence of interactions. The red region, in the upper left portion of the plot represents the interaction between relative pay and new accession mission that result in the most costly conditions for Navy recruiting. This region represents when wages favor the civilian sector and the accession mission is high. The dark blue area represents the opposite conditions, where the total cost of recruiting is the lowest when the accession mission is relatively low and relative pay favors the military.

The contour plot shown in Figure 74 illustrates the relationship between relative pay and recruit accession mission on resources allocated toward advertising.

Figure 74. Three-Dimensional Representation of Relative Pay and NCO Effects Resourcing to Advertising

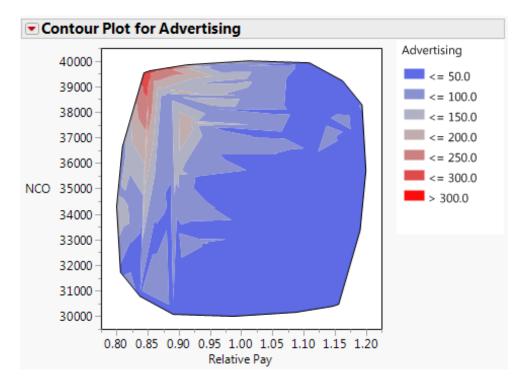


Figure 74, which also exhibits a diagonal nature, indicates that nearly half of the solution space supports a low advertising budget, represented by the dark blue region. The cost of advertising substantially increases when relative pay favors the civilian sector and the accession mission is high, represented by the red region. Once relative pay exceeds approximately 1.00, changes in the new accession mission have little to no effect on the amount of resources allocated to advertising.

2. Test Case 2

To further understand how the addition of two policy uncertainties affect the optimal allocation of recruiting resources, Test Case 2 is explored using JMP. As in the previous section, emphasis is placed on comparing insights gained that may distinguish Test Case 2 from Test Case 1. To gain an initial understanding of the data, Figure 75 shows the span of possible costs of recruiting over each FY.

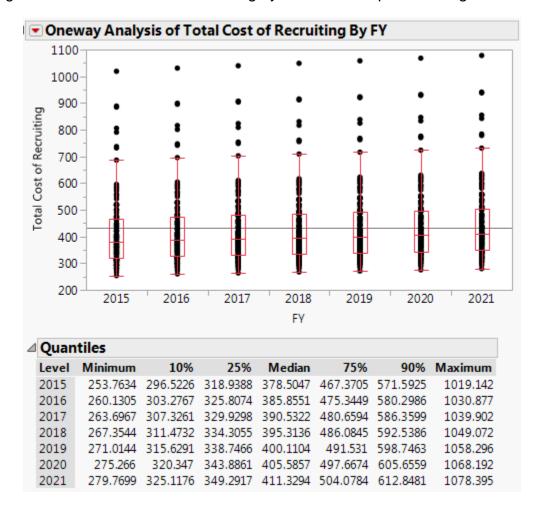


Figure 75. Total Cost of Recruiting by FY with Interguartile Ranges

It is evident that the grand mean total cost of recruiting increased by almost \$50 million in comparison to Test Case 1's grand mean total cost of recruiting shown previously in Figure 58. As well, Figure 76 shows that runs 80, 88, and 96 model conditions result in unusually high expected recruiting costs. From Figure 76, it is difficult to distinguish the difference between runs 80 and 88.

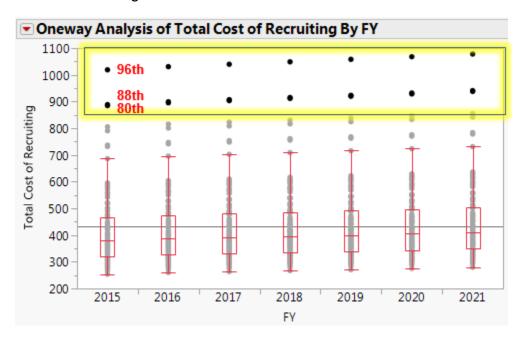


Figure 76. Test Case 2 Outliers

The input values that are common for each run over the seven FY excursion are shown in Table 15. The annual decrease in QMA values is explored later in this section.

Table 15.Test Case 2 Outlier Input Values

	Run #		
	80	88	96
Recruiters	2523	2727	2789
NCO	39688	39453	39609
UE	5.9	5.1	5.1
Relative Pay	0.878125	0.85	0.853125
TSC I-IIIA	0.83	0.71	0.85

In comparison to Test Case 1, where the 96th run was the "least extreme of the extreme" values, the 96th run for Test Case 2 consistently modeled the "most extreme of the extreme" values. This indicates that the increase in recruit quality and annual decrease in QMA affected the optimal allocation of recruiting resources.

Additional insights can be gained by comparing the quantile metrics for both Test Cases. The quantile charts for both test cases are shown in Figure 77.

Quan	tiles						
Level	Minimum	10%	25%	Median	75%	90%	Maximum
2015	251.8643	283.3929	309.1051	349.9401	421.2093	521.9235	959.1079
2016	258.138	289.8711	315.9455	356.89	428.4688	529.2777	968.0586
2017	261.6095	293.5959	320.1883	361.2135	433.1215	533.85	974.1696
2018	265.1709	297.4278	324.5511	365.861	437.8086	538.5172	980.3789
2019	268.7332	301.3375	329.0443	370.5412	442.3917	543.1901	986.5974
2020	272.8857	305.6795	334.2964	375.5285	447.5582	548.4681	993.3847
2021	277.2888	310.3785	339.8189	380.7692	453.0851	554.0022	1000.43
Quan	tiles						
Quan Level	tiles Minimum	10%	25%	Median	75%	90%	Maximum
		10% 296.5226	25% 318.9388	Median 378.5047	75% 467.3705	90% 571.5925	
Level	Minimum						
Level 2015	Minimum 253.7634	296.5226	318.9388	378.5047	467.3705	571.5925	1019.142 1030.877
Level 2015 2016	Minimum 253.7634 260.1305	296.5226 303.2767	318.9388 325.8074	378.5047 385.8551	467.3705 475.3449	571.5925 580.2986	1019.142 1030.877 1039.902
Level 2015 2016 2017	Minimum 253.7634 260.1305 263.6967	296.5226 303.2767 307.3261	318.9388 325.8074 329.9298	378.5047 385.8551 390.5322	467.3705 475.3449 480.6594	571.5925 580.2986 586.3599	1019.142
Level 2015 2016 2017 2018	Minimum 253.7634 260.1305 263.6967 267.3544	296.5226 303.2767 307.3261 311.4732	318.9388 325.8074 329.9298 334.3055	378.5047 385.8551 390.5322 395.3136	467.3705 475.3449 480.6594 486.0845	571.5925 580.2986 586.3599 592.5386	1019.142 1030.877 1039.902 1049.072

Figure 77. Test Case 1 and Test Case 2 Quantile Charts

Top: Test Case 1; bottom: Test Case 2.

Figure 77 helps inform analysts that over each FY, Test Case 2 requires more resources than Test Case 1. The differences between the minimum values for each Test Case are approximately \$2 million across each FY. This spread can increase upwards of \$70 million when comparing differences between maximum values of both cases. As well, the interquartile ranges, the difference between the 25th and 75th quartiles which represent 50 percent of the data, is approximately \$113 million for Test Case 1 and increases to approximately \$150 million for Test Case 2.

Figure 78 juxtaposes the distributions and descriptive statistics for Test Case 1 and Test Case 2.

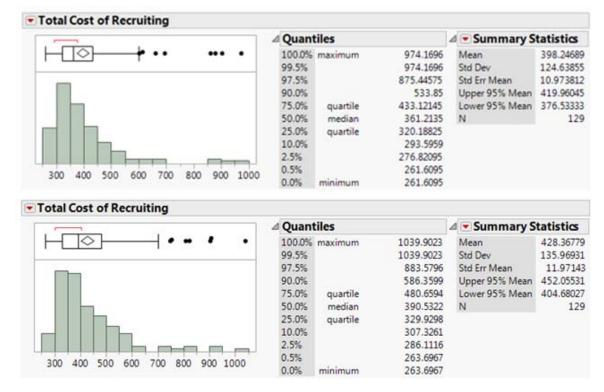


Figure 78. Distributions and Descriptive Statistics for Test Cases 1 and 2

Top: Test Case 1; bottom: Test Case 2.

Figure 78 indicates that the distribution of recruiting costs for Test Case 2 is positively skewed with a long right tail, as was the case for Test Case 1. Test Case 2's right tail appears to be wider than what was seen for Test Case 1. A wider right tail indicates that Test Case 2 produced more expensive combinations of recruiting resources, also referred to as outliers, in comparison to Test Case 1.

When comparing the mean and median values for each Test Case, the differences between the mean and median values for Test Case 1 and Test Case 2 are approximately equal, at \$37 million and \$38 million, respectively. This suggests that the mean total cost of recruiting is heavily influenced by the outliers, but even with the presence of more outliers in Test Case 2, the differences between the mean and median estimators are negligible.

As in Test Case 1, a partition tree identifies advertising as the most influential decision variable for Test Case 2. Figure 79 shows that 62.1 percent of variance in the total cost of recruiting can be explained from a split on advertising.

💌 Partit	ion for To	otal Cost (of Recr	ruiting	
				Number	
	RSquare	RMSE	N	of Splits	AICc
Training	0.621	83.376562	129	1	1513.51
Validation	0.610	85.570007	774		
All Rows					
Count	129	LogWorth	Differe	ence	
Mean	428.36779	57.902778	27	8.86	
Std Dev	135.96931				
•					
Advertisir	ng<117.6716	5 Advertisin	g>=117.	.6716	
Count	106	Count	1	23	
Mean	378.6486	Mean	657.508	43	
Std Dev	62.328299	Std Dev	149.066	37	
▷ Cand	idates	Candi	dates		

Figure 79. First Split for Test Case 2

Following four splits, Figure 80 indicates that when the R-squared value exceeds .80, and even .92 in this case, advertising continues to dominate the partition tree.

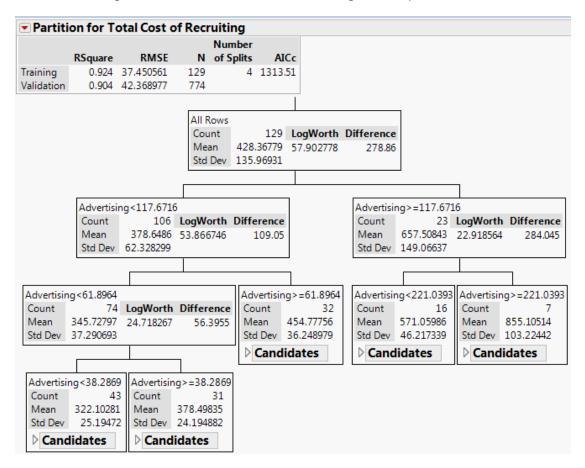


Figure 80. Test Case 2 Following Four Splits

As in Test Case 1, repeated splitting on advertising indicates regression as an appropriate technique for further analysis.

Partition trees are also constructed to determine how uncertainties in QMA and a policy change in recruit quality could affect resourcing to advertising. Here advertising is the response variable and we are investigating which factors influence advertising. Figure 81 shows the first split of this tree.

💌 Partit	ion for A	dvertisin	g		
	DC.	DMCC		Number	
	RSquare	RMSE	N	of Splits	AICc
Training	0.378	47.396588	129	1	1367.78
Validation	0.377	47.81477	774		
All Rows		•			
Count	129	LogWorth	Differe	nce	
Mean	71.101741	20.071571	109.1	121	
	60.307798				
NCO<387	750	NCO>=38	8750		
Count	112	Count	1	17	
Mean	56.721447	Mean	165.84	25	
Std Dev	38.388607	Std Dev	88.8155	51	
▷ Cand	idates	▷ Cand	idates		

Figure 81. Test Case 2: First Split of Advertising

Similar to results found in Test Case 1, the new accession mission is identified as the dominant factor, but it maintains a low variance explained at 37.8 percent. Following three more splits, the R-squared value doubled. The resulting partition tree is shown in Figure 82.

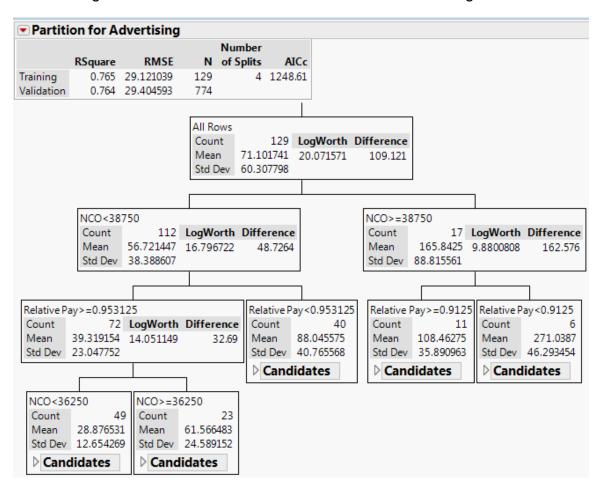


Figure 82. Test Case 2: Partition Tree for Advertising

Figure 82 indicates that the new accession mission and relative pay predominately drive the allocation of resources to advertising. It is interesting to note that neither QMA nor recruit quality appear in this partition tree. This suggests that they have a minimal, if any, influence on advertising resources.

Again, stepwise regression with manual judgement, is used to formulate a model to predict the total cost of recruiting for Test Case 2. The parameter estimates used to formulate the prediction model are shown in Figure 83.

Parameter Estimates				
Term	Estimate	Std Error	t Ratio	Prob> t
Intercept	-126.5045	74.71878	-1.69	0.0931
NCO	0.0266897	0.001086	24.57	<.0001*
TSC I-IIIA	562.69782	72.19942	7.79	<.0001*
Unemployment	-33.33182	2.715898	-12.27	<.0001*
Relative Pay	-662.512	27.15714	-24.40	<.0001*
(NCO-35000.1)*(Unemployment-6.0031)	-0.005165	0.001003	-5.15	<.0001*
(NCO-35000.1)*(Relative Pay-1)	-0.120308	0.010921	-11.02	<.0001*
(TSCI-IIIA-0.77504)*(Relative Pay-1)	-2866.773	673.4763	-4.26	<.0001*
(Unemployment-6.0031)*(Relative Pay-1)	135.38315	24.1139	5.61	<.0001*
(NCO-35000.1)*(NCO-35000.1)	2.3921e-6	4.485 e -7	5.33	<.0001*
(Relative Pay-1)*(Relative Pay-1)	1980.2703	278.714	7.11	<.0001*

Figure 83. Test Case 2, Stepwise Regression for Total Cost of Recruiting

The parameter estimates shown in Figure 83, formulate the prediction model shown in Figure 84.

Figure 84. Test Case 2, Prediction model for Total Cost of Recruiting

Prediction Expression
-126.5044997643
+ 0.02668971455148 * NCO
+ 562.697816223402 * TSC I-IIIA
+ -33.3318158052 * Unemployment
+ -662.51203008942 * Relative Pay
+ $(NCO - 35000.0620155039) * ((Unemployment - 6.0031007751938) * -0.0051646636056)$
+ (NCO - 35000.0620155039)*((Relative Pay - 1)* -0.1203081976383)
+ (TSC I-IIIA - 0.77503875968992)*((Relative Pay - 1)* -2866.7729142712)
+ (Unemployment - 6.0031007751938)*((Relative Pay - 1)* 135.383146993767)
+ (NCO - 35000.0620155039)*((NCO - 35000.0620155039)*0.00000239213948)
+ (Relative Pay - 1)*((Relative Pay - 1)* 1980.27034394266)

As in Test Case 1, this prediction model indicates the presence of variable interactions and non-linear effects. Test Case 2 appears to be highly influenced by multi-variable interactions. Where Test Case 1 had just one multi-variable interaction and two quadratic terms, Test Case 2's prediction model has four multi-variable interactions and two quadratic terms. The regression model shown in Figure 84 provides evidence to believe that the addition of these two policy uncertainties (i.e., percentage of high quality recruits and decrease in QMA) does increase the complexity of recruiting resource allocation and effects the total cost of recruiting.

The summary of fit for Test Case 2's prediction model is shown in Figure 85.

Figure 85. Summary of Fit for Test Case 2's Prediction Model for Total Cost of Recruiting

Summary of Fit	
RSquare	0.935761
RSquare Adj	0.930318
Root Mean Square Error	35.89242
Mean of Response	428.3678
Observations (or Sum Wgts)	129

This prediction model explains over 93 percent of the variance in the total cost of recruiting.

The actual versus predicted plot in Figure 86 illustrates how the prediction model compares to the actual data for FY 2017.

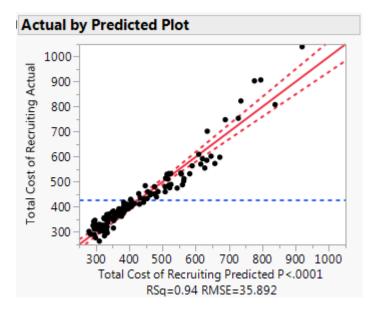
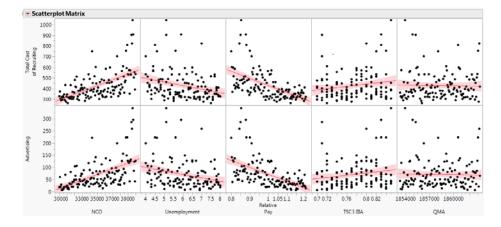


Figure 86. Test Case 2, Actual versus Predicted Plot

The factors that were determined to be influential through the partition tree and stepwise regression are fit in scatterplot matrices to visualize trends or relationships of the data, as shown in Figure 87. QMA was also included for comparison even though it is not considered an influential factor.

Figure 87. Test Case 2: Scatterplot Matrices of Influential Factors



As in Test Case 1, relative pay and NCO follow similar trends. Both scatterplot graphs for the percentage of high quality recruits show a slightly

upward linear trend. This indicates that an increased percentage of high quality recruits requires more resourcing to advertising, thus resulting in high overall recruiting costs. Both unemployment rate graphs show a slight downward trend, indicating that the total cost of recruiting and the total cost of advertising decreases as the unemployment rate increases. The recruit quality scatterplots suggest that as the requirement for recruit quality increases, more funds need to be allocated to advertising and the total cost of recruiting increases. Both scatterplots for QMA do not indicate any discernible trends.

D. FULL FACTORIAL COMPARISON

The NOLH DOE technique is the foundation for PROM-WED's data farming wrapper. Coupled with PROM-WED's GUI, users are able to design, populate, and execute space-filling experimental designs quickly and easily. Without the NOLH DOE, PROM-WED's data farming wrapper would not be as effective.

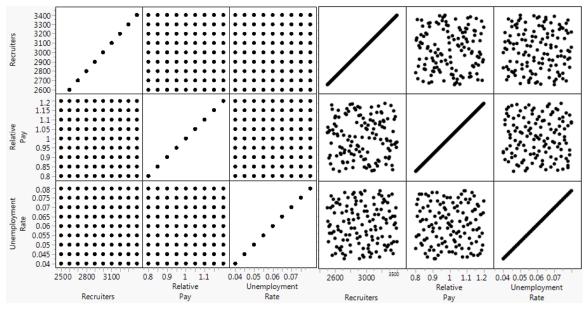
As previously described in Chapter II, the NOLH DOE method is an alternative to the straightforward full factorial method. A modified version of Test Case 1 is used to demonstrate what a potential full factorial could look like. This design tests three variables at only nine levels each. Table 16 shows an illustrative example of what nine levels for each variable could look like.

Levels	Relative Pay	Unemployment Rate	Recruiters
1	0.80	4.0%	30,000
2	0.85	4.5%	31,000
3	0.90	5.0%	32,000
4	0.95	5.5%	33,000
5	1.00	6.0%	34,000
6	1.05	6.5%	35,000
7	1.10	7.0%	36,000
8	1.15	7.5%	37,000
9	1.20	8.0%	38,000

 Table 16.
 Full Factorial Levels for Modified Test Case 1

In comparison to the NOLH DOE, where each variable is tested at either 33 or 129 levels, for this full factorial example each variable is tested over only nine levels. To test all possible variable interactions the full factorial DOE would have to be run over 729 input combinations for each FY. 729 runs for each FY results in 5,103 runs for all seven FY's. This is in comparison to 231 runs for the 33-point NOLH design, or 903 runs for the 129-point NOLH design, which account for all runs over all seven FYs. The pairwise scatterplot matrices of a multi-level full factorial design in comparison to the 129 design point NOLH are shown in Figure 88.





Left: Full Factorial. Right: 128-point NOLH DOE.

As is evident by these pairwise plots, the NOLH DOE is able to execute space-filling designs with a fraction of runs.

Not only is the NOLH DOE method an efficient and effective alternative to the factorial DOE method, PROM-WED demonstrates that the NOLH DOE can be embedded into a model to add a robust data farming capability. The NOLH DOE algorithm built in Microsoft Excel by the SEED Center for Data Farming at NPS provides this capability. Statistical software packages, like JMP, have a factorial DOE capability. However, to use this method an analyst would have to build the factorial DOE in JMP and import the design into Microsoft Excel. Embedding the NOLH DOE within the legacy PRO model alleviates this extra step, while also providing analysts with enhanced analytic abilities through efficient and effective space-filling designs that provide opportunities for robust sensitivity and risk analysis.

E. DISCUSSION

PROM-WED is an enhanced analytic tool capable of providing PRO model users with insights to better inform recruiting resource allocation decisions. The legacy PRO model produces a point-solution output, as shown in Figure 89.

Resource Run	2015	2016	2017	2018	2019	2020	2021
NCO	35,025	36,425	36,800	35,800	35,225	34,650	34,650
Capacity	N/A						
Unemployment (%)	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Total Recruiters	3,913	3,685	3,685	3,685	3,685	3,685	3,685
Total Recruiter Cost (\$M)	\$320.488	\$305.122	\$309.699	\$314.344	\$319.059	\$324.618	\$330.274
Advertising (\$M)	\$102.921	\$264.167	\$261.119	\$184.724	\$142.227	\$115.543	\$113.903
Enlistment Bonus (\$M)	\$40.971	\$36.580	\$41.340	\$40.650	\$42.230	\$42.060	\$42.810
Education Incentives (\$M)	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000	\$0.000
LRP (\$M)	\$7.440	\$11.220	\$11.280	\$11.380	\$11.430	\$11.460	\$11.670
HSDG	95%	95%	95%	95%	95%	95%	95%
TSC I-IIIA	70%	70%	70%	70%	70%	70%	70%
Total Cost (\$M)	\$471.820	\$617.089	\$623,438	\$551,098	\$514,946	\$493,681	\$498,656

Figure 89. Legacy PRO Model Output

POM FY17 version of the PRO model.

As showcased in this chapter, PROM-WED provides users with the ability to efficiently and effectively grow space-filling designs that produce data sets of 33 or 129 points in minutes. This means that 33 or 129 data points as shown in Figure 89 are produced by only one run of PROM-WED. PROM-WED not only grows data, it also facilitates basic statistical analysis and allows for further exploration using a statistical software package to better inform decision makers on the optimal allocation of hundreds of millions of dollars to advertisements, enlistment bonuses, and recommended number of Navy recruiters in the field. THIS PAGE INTENTIONALLY LEFT BLANK

V. CONCLUSIONS AND RECOMMENDATIONS

Through design of experiment techniques, PROM-WED provides PRO model users with an enhanced analytic tool capable of producing valuable insights into the optimal allocation of recruiting resources. Based on the findings of this study, each research question presented in Chapter I is answered. Recommendations for further work are also presented.

A. RESEARCH QUESTION 1

How can design of experiment techniques better inform decision maker's determination of the optimal and robust combination of recruiting resources?

Efficient DOE techniques help better inform decision makers on the optimal allocation of recruiting resources through the efficient and effective implementation of space-filling designs. Embedding the PRO model into a data farming environment provides users with the ability to execute space-filling design of experiments. Through a single PROM-WED excursion, it is possible to test 33 or 129 legacy PRO model scenarios. Each excursion is able to test how uncertainties and variations in controllable and uncontrollable factors may affect the allocation of recruiting resources. In this study, Test Case 1 and Test Case 2 are proof-of-concept examples. As demonstrated through Test Case 1, the most expensive resource is the number of recruiters in the field. However, it is apparent that the total cost of recruiting is highly dependent upon the allocation of funds to advertising. In order from high to low influence: the new accession mission, relative pay, and unemployment rate drive the amount of resources allocated to advertising. As for the additional policy factors included in the legalization of marijuana scenario explored in Test Case 2, there is evidence to believe that increasing the percentage of high quality recruits has a greater effect on the total cost of recruiting than the decrease in QMA. These few examples show only a small spectrum of the vast amount of information that PROM-WED can provide. Therefore, by using DOE techniques, PROM-WED is able to grow PRO model data in a systematic and controlled way. By controlling variable uncertainties and interactions, analysts are able to gain insights such as the ones just described. These insights help better inform decision makers on determining the optimal and robust allocation of recruiting resources.

B. RESEARCH QUESTION 2

How can efficient design of experiment techniques be incorporated into the PRO model for future, on-the-spot risk, and sensitivity analysis?

The PRO model is embedded into a data farming environment through the implementation of the Microsoft Excel NOLH DOE algorithm made available by the SEED Center for Data Farming. An enhanced GUI allows users to populate the NOLH DOE worksheet for each factor they would like to vary. The NOLH DOE algorithm automatically generates values for either 33 or 129 levels for each variable. Code is written to loop over each combination of 33 or 129 different scenarios. The result is a data set of 33 or 129 PRO model runs for each PROM-WED excursion. PROM-WED provides automatically generated analysis in Microsoft Excel for on-the-spot risk and sensitivity analysis. To take advantage of the space-filling qualities that the NOLH DOE provides, results from using the 129-point design can be explored using any available software package, like JMP.

C. RESEARCH QUESTION 3

Can an enhanced PRO model give decision-makers a robust solution for the optimal allocation of recruiting resources?

An enhanced PRO model allows analysts to understand how uncertainties and fluctuations in controllable and uncontrollable factors affect the allocation of recruiting resources. A robust solution can be interpreted through two lenses: (1) resiliency, or (2) gained insight. A robust solution for the optimal allocation of recruiting resources in terms of resiliency is one that is not overly affected by variations in uncontrollable factors, to include economic uncertainties such as unemployment rates, or controllable factors, such as increasing the percentage of high quality recruits. Test Case 1 provides insights to decision makers regarding the optimal allocation of recruiting resources that is impervious to best case, worst case, and most likely economic conditions. For example, comparing the program of record and PROM-WED's allocation of recruiting resources for Test Case 1, there is evidence to believe that the pre-determined recruiting allocation budget was within the same range of spending as PROM-WED's solution.

An alternative approach to interpreting robustness is through assessing the value of information gained through the data. PROM-WED provides analysts with the capability to data farm the PRO model. Using data farming, PROM-WED grows PRO model data in an efficient and space-filling way. Improved understanding of the solution space can range from basic sensitivity and risk analysis of the decision variables presented in PROM-WED's automatically generated decision support capability, to gaining insights into how uncertainties in input factors affect the optimal allocation of recruiting resources using a software package like JMP. Valuable insights like these help analysts better inform decision-makers on how factors such as uncertain unemployment rates, a proposed policy change, or constrained resources can affect the optimal allocation of recruiting resources.

D. FUTURE WORK

The focus of this research was to enhance the existing PRO model with an efficient design of experiments capability. PROM-WED successfully data farms the PRO model's traditional run option. Recommendations for further work are separated into three sections. The first section addresses additional ways to improve PROM-WED. The second section addresses the opportunity to study and improve the PRO model's underlying mathematical construct. The last section addresses the opportunity to enhance any Microsoft Excel based model with techniques or methods employed in this research.

1. Capacity Run Capability and Additional Design Options

Further work is recommended to enhance PROM-WED with the addition of the capacity run option along with more design of experiment choices. While the capacity run option was briefly explored as a part of this research, additional work needs to be done to ensure that the data farming wrapper correctly enters input values in the appropriate locations within the PRO model's simulation worksheets, and extracts the correct output data. Once the data farming wrapper for the capacity run option is complete, its automatically generated decision support capability can be refined. Figure 90 shows a graph that a senior analyst at N1 requested to be included in the capacity run's automatically generated decision support analysis.

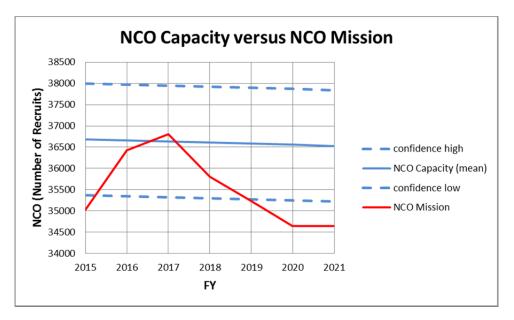


Figure 90. Example Capacity Run Graph

The new accession mission is shown in red and the expected capacity with a 95 percent confidence interval is shown in blue. This graph illustrates where the Navy has either budgeted an excess or deficient amount of resources to meet the recruiting mission. For example, in FYs 2020 and 2021, the Navy can expect to recruit approximately 36,500 new recruits each year when only approximately 34,650 are needed. Since the NCO missions for FYs 2016, 2017, and 2018 are within the 95 percent confidence interval, there is evidence to believe that the pre-determined allocation of recruiting resources will be sufficient for those FYs.

Along with fully integrating the capacity run option into PROM-WED, work can be done to add other designs to PROM-WED's data farming wrapper. This will allow analysts to explore a broader realm of possibilities to gain additional insights about the complex solution space.

2. Recruiting Cost Function

For the purpose of this research, it was assumed that the PRO model accurately models active duty enlisted recruiting resource allocation. If this assumption were relaxed, the following additional research is suggested.

Within the "black box" of the recruiting cost function, elasticities can act as another variable with uncertainties. Currently, the elasticities are updated annually based on actual data from the previous FY. Therefore, further work can be done to include elasticities within PROM-WED's data farming wrapper. Also, future work can be done to explore the relevancy of the recruiting cost function in current recruiting practice.

The Navy is interested in incorporating the active duty officer, reserve officer, and reserve enlisted recruiting missions into the PRO model. This is a unique challenge since there are many diverse and unique communities within the active duty officer corps alone that require targeted recruiting initiatives. For example, Navy Doctors are often incentivized to join the Navy through a loan repayment program that alleviates medical school debt, or signing bonuses. On the other hand, loan repayment programs and signing bonuses are not available to prospective general line officers. Consequently, to recruit general line officers, large amounts of recruiting resources may be allocated to advertising in order to pay for college career fair booths. Therefore, future work can be done to adapt the recruiting cost function to model the attributes of each unique recruiting mission. This additional work will provide analysts with an enhanced model that can help decision makers determine the optimal allocation of recruiting resources for the full spectrum of Navy recruiting.

3. Apply Data Farming to Another Model!

The methodology used to develop PROM-WED can be applied to any model built in Microsoft Excel. The NOLH DOE algorithms can be embedded into any Microsoft Excel model. Code similar to what is found in Appendix B can be written to loop over each design point of the NOLH. The resulting product is an enhanced tool that provides an efficient way to construct, run, and analyze a model using space-filling experimental designs.

APPENDIX A. 129-POINT NOLH DOE WORKSHEET

2 low level	0.0001	0.04	3913	7.44	34.8264	40.971	35025	0.7	0.95	0.4	1883304
3 high level	0.0001	0.04	3913	7.44	34.8264		35025	0.7	0.95		1883304
4 decimals	4	2 Unemployment Rate	0	3 LRP	3 Advertising (AC Enl. Only)	3	0 NCO (50% BoY DEP)	2	2	6 Deletive Dev	0
5 stor name	0.0001	0.04	3913	7.44	Advertising (AC Eni. Only) 34.826		NCO (50% BOT DEP) 35025	0.7	0.95		QMA 1883304
7 2017	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
8	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
9	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95		1883304
10	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
11	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95	0.4	
12 13	0.0001 0.0001	0.04 0.04	3913 3913	7.44 7.44	34.826 34.826		35025 35025	0.7 0.7	0.95		1883304 1883304
14	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
15	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		
16	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
17	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95		1883304
18	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
19	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
20 21	0.0001 0.0001	0.04	3913 3913	7.44 7.44	34.826 34.826		35025 35025	0.7 0.7	0.95 0.95	0.4	1883304 1883304
22	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
23	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
24	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
25	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95	0.4	1883304
26	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
27	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
28 29	0.0001 0.0001	0.04	3913 3913	7.44 7.44	34.826 34.826		35025 35025	0.7 0.7	0.95 0.95	0.4	1883304 1883304
30	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
31	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
32	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95	0.4	1883304
33	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95	0.4	
34	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
35 36	0.0001 0.0001	0.04	3913	7.44 7.44	34.826 34.826		35025	0.7	0.95 0.95		1883304
36	0.0001	0.04	3913 3913	7.44	34.826 34.826		35025 35025	0.7 0.7	0.95		1883304 1883304
38	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95	0.4	
39	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
40	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95	0.4	1883304
41	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
42	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
43 44	0.0001 0.0001	0.04 0.04	3913 3913	7.44 7.44	34.826 34.826		35025 35025	0.7 0.7	0.95		1883304 1883304
44	0.0001	0.04	3913 3913	7.44	34.826 34.826		35025	0.7	0.95	0.4	
45	0.0001	0.04	3913	7.44	34.826		35025	0.7	0.95		1883304
47	0.0001	0.04	3913	7.44		40.971	35025	0.7	0.95	0.4	1883304
48	0.0001	0.04	3913	7.44	34.826	40.971	35025	0.7	0.95	0.4	1883304

49	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
50	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
51	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
				7.44					
52	0.0001	0.04	3913		34.826 40.971	35025		0.95 0.4 188330	
53	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
54	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
55	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
56	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
57	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
58	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
59	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
60	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
61	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
62	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
63			3913	7.44		35025		0.95 0.4 188330	
	0.0001	0.04			34.826 40.971				
64	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
65	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
66	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
67	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
68	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
69	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
70	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
71	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
72	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
73	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
74	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
75	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
76	0.0001	0.04	3913	7.44	34.826 40.971	35025			
77	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
78	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
79	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
80	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
81	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
82	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
83	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
84	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
85	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
86	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
87	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
88	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
89	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
90	0.0001	0.04	3913	7.44	34.826 40.971	35025		0.95 0.4 188330	
91	0.0001	0.04	3913	7.44	34.826 40.971	35025	0.7 0	0.95 0.4 188330	J4
91 92	0.0001 0.0001	0.04 0.04	3913 3913			35025 35025		0.95 0.4 188330 0.95 0.4 188330	
92	0.0001	0.04	3913	7.44 7.44	34.826 40.971 34.826 40.971	35025	0.7 0	0.95 0.4 188330)4
				7.44	34.826 40.971		0.7 0)4
92 93	0.0001 0.0001	0.04 0.04	3913 3913	7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971	35025 35025	0.7 (0.7 (0.95 0.4 188330 0.95 0.4 188330)4)4
92 93 94	0.0001 0.0001 0.0001	0.04 0.04 0.04	3913 3913 3913	7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025	0.7 0 0.7 0 0.7 0	0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330)4)4)4
92 93 94 95	0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025	0.7 0 0.7 0 0.7 0 0.7 0	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(04 04 04 04
92 93 94 95 96	0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025	0.7 0 0.7 0 0.7 0 0.7 0 0.7 0	0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330)4)4)4)4)4
92 93 94 95 96 97	0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025	0.7 0 0.7 0 0.7 0 0.7 0 0.7 0 0.7 0	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4
92 93 94 95 96	0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025	0.7 0 0.7 0 0.7 0 0.7 0 0.7 0 0.7 0	0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330 0.95 0.4 188330)4)4)4)4)4)4
92 93 94 95 96 97	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025	0.7 (0.7 (0.7 (0.7 (0.7 (0.7 (0.7 (0.7 (0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4
92 93 94 95 96 97 98 99	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34 826 40.971 34 826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 0 0.7 0 0.7 0 0.7 0 0.7 0 0.7 0 0.7 0 0.7 0	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4
92 93 94 95 96 97 98 99 99 100	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0 0.7 (0	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4
92 93 94 95 96 97 98 99 99 100 101	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 (0 0.7 (0)	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4
92 93 94 95 96 97 98 99 90 100 101 102	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34 826 40.971 34 826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 (0 0.7 (0)	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4
92 93 94 95 96 97 98 99 100 101 102 103	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 0 0.7 0	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4
92 93 94 95 96 97 98 99 100 100 100 101 102 103 104	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34 826 40.971 34 826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 100 100 101 102 103 104	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 102 103 104 105 106	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 99 100 101 102 103 104 105 106 107	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 100 100 101 102 103 104 104 105 106 107 108	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18833()4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 99 99 100 101 101 102 103 104 105 106 107 108 109 110	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7,44 7,44 7,44 7,44 7,44 7,44 7,44 7,44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 99 99 100 101 101 102 103 104 105 106 107 108 109 110	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7,44 7,44 7,44 7,44 7,44 7,44 7,44 7,44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 111 113 113	0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 113 114	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 100 101 102 103 104 105 106 107 100 108 109 111 111 112 113 114 115	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 107 108 109 110 111 112 113 114 115 116	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 116 117 117	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 107 108 109 110 111 112 113 114 115 116	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 116 117 117	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 106 107 108 109 110 111 112 113 114 115 116 117 118 119 119	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 113 114 115 116 117 118 119 120	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 111 112 113 111 115 116 116 117 118 119 120 121	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 121 122 122	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 117 118 119 120 121 122 122 123	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4)4)4)4)4)4)4)4)4)4)4)4)
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 1117 118 119 120 121 122 123 123 124	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18	04 04
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 117 118 119 120 121 122 122 123	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 111 112 113 114 115 116 117 118 119 120 121 121 122 123 124 125	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 107 108 109 111 111 112 113 114 115 116 117 118 116 117 118 119 120 121 122 123 124 125 126 126	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	34.826 40.971 34.826 40.971	35025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18	04 04
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 100 110 111 112 113 114 115 116 1117 118 119 120 121 122 123 124 125 126 127	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	04 04
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 121 122 123 124 125 126 127 128	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	0.95 0.4 18833(0.95 0.4 18)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 107 108 109 110 111 112 113 114 116 117 118 116 117 118 119 120 121 122 122 123 124 125 126 127 128 129	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 113 114 115 116 117 118 120 121 122 123 124 125 126 127 128 129 130 130	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 107 108 109 110 111 112 113 114 116 117 118 116 117 118 119 120 121 122 122 123 124 125 126 127 128 129	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4
92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 113 114 115 116 117 118 120 121 122 123 124 125 126 127 128 129 130 130	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	04 04
92 93 94 95 96 97 98 99 90 100 101 102 103 104 105 106 107 108 108 109 110 111 112 113 114 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 131	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	35025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	04 04
92 93 94 95 96 97 98 99 100 101 102 103 104 106 107 108 109 111 111 111 112 113 114 115 116 117 118 119 120 121 121 122 123 124 126 126 127 128 129 130 131 131	0.0001 0.0001	0.04 0.04 0.04 0.04 0.04 0.04 0.04 0.04	3913 3913 3913 3913 3913 3913 3913 3913	7.44 7.44 7.44 7.44 7.44 7.44 7.44 7.44	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	36025 35025	0.7 C 0.7 C	$\begin{array}{cccccccccccccccccccccccccccccccccccc$)4)4

APPENDIX B. DATA FARMING SUBROUTINE

Option Explicit Sub NOLH33loop() 'FY Loop

Dim wsNames As Variant Dim wsCurrent As Variant Dim I As Long Dim j As Long

wsNames = Array("Sheet6," "Sheet10," "Sheet11," "Sheet12," "Sheet13," "Sheet14," "Sheet15")

For Each wsCurrent In wsNames

'With Worksheets(wsCurrent) If wsCurrent = "Sheet6" Then Call NOLH33input15 If wsCurrent = "Sheet10" Then Call NOLH33input16 If wsCurrent = "Sheet11" Then Call NOLH33input17 If wsCurrent = "Sheet12" Then Call NOLH33input18 If wsCurrent = "Sheet13" Then Call NOLH33input19 If wsCurrent = "Sheet14" Then Call NOLH33input20 If wsCurrent = "Sheet15" Then Call NOLH33input21 Next wsCurrent

End Sub

Sub NOLH33input15()

Dim iterationNum As Long

'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet6.Range("A7")

For iterationNum = 1 To 33

'Ed Benefits Sheet5.Range("D17") = Sheet6.Range("B" & 4 + iterationNum)

'UE Rates Sheet9.Range("C50") = 100 * Sheet6.Range("C" & 4 + iterationNum)

'Recruiters Sheet5.Range("D19") = Sheet6.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet6.Range("E" & 4 + iterationNum) 'Advertisina Sheet5.Range("D21") = Sheet6.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("D22") = Sheet6.Range("G" & 4 + iterationNum) **NCO** Sheet9.Range("E11") = Sheet6.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet6.Range("H" & 4 + iterationNum) 'Sheet5.Range("D12") = Sheet6.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet6.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet6.Range("J" & 4 + iterationNum) 'Relative Pay Sheet5.Range("D24") = Sheet6.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet6.Range("L" & 4 + iterationNum) ' 'Update Model year on Sim Tab ' Sheet9.Range("B3") = Sheet6.Range("A7") Call RunTraditional6 Sheet24.Range("B" & 1 + iterationNum) = Sheet3.Range("D3") 'NCO -> output 'Sheet24.Range("B" & 1 + iterationNum) = Sheet3.Range("D4") 'NCO cap -> output Sheet24.Range("C" & 1 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 1 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 1 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output Sheet24.Range("F" & 1 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output

Sheet24.Range("G" & 1 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 1 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 1 + iterationNum) = Sheet6.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 1 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 1 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 1 + iterationNum) = Sheet6.Range("K" & 4 + iterationNum) 'Relative Pay Sheet24.Range("M" & 1 + iterationNum) = Sheet6.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 1 + iterationNum) = Sheet6.Range("A7") Next iterationNum End Sub Sub NOLH33input16() Dim iterationNum As Long 'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet10.Range("A7") For iterationNum = 1 To 33 'Ed Benefits Sheet5.Range("E17") = Sheet10.Range("B" & 4 + iterationNum) 'UE Rates Sheet9.Range("C50") = 100 * Sheet10.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("E19") = Sheet10.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet10.Range("E" & 4 + iterationNum) 'Advertising Sheet5.Range("E21") = Sheet10.Range("F" & 4 + iterationNum)

'EΒ

Sheet5.Range("E22") = Sheet10.Range("G" & 4 + iterationNum) **NCO** Sheet9.Range("E11") = Sheet10.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet10.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet10.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet10.Range("J" & 4 + iterationNum) 'Relative Pay Sheet5.Range("D24") = Sheet10.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet10.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 34 + iterationNum) = Sheet3.Range("D3") 'NCO -> output 'Sheet24.Range("B" & 34 + iterationNum) = Sheet3.Range("D4") 'NCO cap -> output Sheet24.Range("C" & 34 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 34 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 34 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output Sheet24.Range("F" & 34 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 34 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 34 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 34 + iterationNum) = Sheet10.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 34 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 34 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 34 + iterationNum) = Sheet10.Range("K" & 4 + iterationNum) 'Relative Pay

Sheet24.Range("M" & 34 + iterationNum) = Sheet10.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 34 + iterationNum) = Sheet10.Range("A7") Next iterationNum End Sub Sub NOLH33input17() Dim iterationNum As Long 'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet11.Range("A7") For iterationNum = 1 To 33'Ed Benefits Sheet5.Range("F17") = Sheet11.Range("B" & 4 + iterationNum) **'UE Rates** Sheet9.Range("C50") = 100 * Sheet11.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("F19") = Sheet11.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet11.Range("E" & 4 + iterationNum) 'Advertising Sheet5.Range("F21") = Sheet11.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("F22") = Sheet11.Range("G" & 4 + iterationNum) **'NCO** Sheet9.Range("E11") = Sheet11.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet11.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet11.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet11.Range("J" & 4 + iterationNum)

'Relative Pav Sheet5.Range("D24") = Sheet11.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet11.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 67 + iterationNum) = Sheet3.Range("D3") 'NCO -> output Sheet24.Range("C" & 67 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 67 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 67 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output Sheet24.Range("F" & 67 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 67 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 67 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 67 + iterationNum) = Sheet11.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 67 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 67 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 67 + iterationNum) = Sheet11.Range("K" & 4 + iterationNum) 'Relative Pay Sheet24.Range("M" & 67 + iterationNum) = Sheet11.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 67 + iterationNum) = Sheet11.Range("A7") Next iterationNum End Sub Sub NOLH33input18() Dim iterationNum As Long 'Update Model year on Sim Tab

Sheet9.Range("B3") = Sheet12.Range("A7")

For iterationNum = 1 To 33'Ed Benefits Sheet5.Range("G17") = Sheet12.Range("B" & 4 + iterationNum) 'UE Rates Sheet9.Range("C50") = 100 * Sheet12.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("G19") = Sheet12.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet12.Range("E" & 4 + iterationNum) 'Advertising Sheet5.Range("G21") = Sheet12.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("G22") = Sheet12.Range("G" & 4 + iterationNum) 'NCO Sheet9.Range("E11") = Sheet12.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet12.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet12.Range("I" & 4 + iterationNum) **'HSDG** Sheet5.Range("N16") = Sheet12.Range("J" & 4 + iterationNum) 'Relative Pay Sheet5.Range("D24") = Sheet12.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet12.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 100 + iterationNum) = Sheet3.Range("D3") 'NCO -> output Sheet24.Range("C" & 100 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 100 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 100 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output

Sheet24.Range("F" & 100 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 100 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 100 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 100 + iterationNum) = Sheet12.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 100 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 100 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 100 + iterationNum) = Sheet12.Range("K" & 4 + iterationNum) 'Relative Pay Sheet24.Range("M" & 100 + iterationNum) = Sheet12.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 100 + iterationNum) = Sheet12.Range("A7") Next iterationNum End Sub Sub NOLH33input19() Dim iterationNum As Long 'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet13.Range("A7") For iterationNum = 1 To 33 'Ed Benefits Sheet5.Range("H17") = Sheet13.Range("B" & 4 + iterationNum) **'UE Rates** Sheet9.Range("C50") = 100 * Sheet13.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("H19") = Sheet13.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet13.Range("E" & 4 + iterationNum) 'Advertising

Sheet5.Range("H21") = Sheet13.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("H22") = Sheet13.Range("G" & 4 + iterationNum) **NCO** Sheet9.Range("E11") = Sheet13.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet13.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet13.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet13.Range("J" & 4 + iterationNum) 'Relative Pay Sheet5.Range("D24") = Sheet13.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet13.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 133 + iterationNum) = Sheet3.Range("D3") 'NCO -> output Sheet24.Range("C" & 133 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 133 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 133 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output Sheet24.Range("F" & 133 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 133 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 133 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 133 + iterationNum) = Sheet13.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 133 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 133 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 133 + iterationNum) = Sheet13.Range("K" & 4 + iterationNum) 'Relative Pay

Sheet24.Range("M" & 133 + iterationNum) = Sheet13.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 133 + iterationNum) = Sheet13.Range("A7") Next iterationNum End Sub Sub NOLH33input20() Dim iterationNum As Long 'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet14.Range("A7") For iterationNum = 1 To 33'Ed Benefits Sheet5.Range("I17") = Sheet14.Range("B" & 4 + iterationNum) **'UE Rates** Sheet9.Range("C50") = 100 * Sheet14.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("I19") = Sheet14.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet14.Range("E" & 4 + iterationNum) 'Advertising Sheet5.Range("I21") = Sheet14.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("I22") = Sheet14.Range("G" & 4 + iterationNum) **'NCO** Sheet9.Range("E11") = Sheet14.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet14.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet14.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet14.Range("J" & 4 + iterationNum)

'Relative Pav Sheet5.Range("D24") = Sheet14.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet14.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 166 + iterationNum) = Sheet3.Range("D3") 'NCO -> output Sheet24.Range("C" & 166 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 166 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 166 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output Sheet24.Range("F" & 166 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 166 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 166 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 166 + iterationNum) = Sheet14.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 166 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 166 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 166 + iterationNum) = Sheet14.Range("K" & 4 + iterationNum) 'Relative Pay Sheet24.Range("M" & 166 + iterationNum) = Sheet14.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 166 + iterationNum) = Sheet14.Range("A7") Next iterationNum End Sub Sub NOLH33input21() Dim iterationNum As Long

'Update Model year on Sim Tab Sheet9.Range("B3") = Sheet15.Range("A7")

For iterationNum = 1 To 33'Ed Benefits Sheet5.Range("J17") = Sheet15.Range("B" & 4 + iterationNum) 'UE Rates Sheet9.Range("C50") = 100 * Sheet15.Range("C" & 4 + iterationNum) 'Recruiters Sheet5.Range("J19") = Sheet15.Range("D" & 4 + iterationNum) **LRP** Sheet5.Range("D20") = Sheet15.Range("E" & 4 + iterationNum) 'Advertising Sheet5.Range("J21") = Sheet15.Range("F" & 4 + iterationNum) 'EB Sheet5.Range("J22") = Sheet15.Range("G" & 4 + iterationNum) 'NCO Sheet9.Range("E11") = Sheet15.Range("H" & 4 + iterationNum) 'Sheet5.Range("D23") = Sheet15.Range("H" & 4 + iterationNum) **'TSC I-IIIA** Sheet5.Range("N17") = Sheet15.Range("I" & 4 + iterationNum) 'HSDG Sheet5.Range("N16") = Sheet15.Range("J" & 4 + iterationNum) 'Relative Pay Sheet5.Range("D24") = Sheet15.Range("K" & 4 + iterationNum) 'QMA Sheet5.Range("D25") = Sheet15.Range("L" & 4 + iterationNum) Call RunTraditional6 Sheet24.Range("B" & 199 + iterationNum) = Sheet3.Range("D3") 'NCO -> output Sheet24.Range("C" & 199 + iterationNum) = Sheet3.Range("D5") 'Unemployment -> output Sheet24.Range("D" & 199 + iterationNum) = Sheet3.Range("D6") 'total recruiters -> output Sheet24.Range("E" & 199 + iterationNum) = Sheet3.Range("D7") 'total recruiters cost to output

Sheet24.Range("F" & 199 + iterationNum) = Sheet3.Range("D8") 'advertising \$ to output Sheet24.Range("G" & 199 + iterationNum) = Sheet3.Range("D9") 'EB \$ to output Sheet24.Range("H" & 199 + iterationNum) = Sheet3.Range("D10") 'ED \$ to output to output Sheet24.Range("I" & 199 + iterationNum) = Sheet15.Range("E" & 4 + iterationNum) 'wsResultsFY15.Range("I" & 1 + designNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'LRP \$ - a constant to output Sheet24.Range("J" & 199 + iterationNum) = Sheet3.Range("D12") 'HSDG% to output Sheet24.Range("K" & 199 + iterationNum) = Sheet3.Range("D13") 'UMG% to output Sheet24.Range("L" & 199 + iterationNum) = Sheet15.Range("K" & 4 + iterationNum) 'Relative Pay Sheet24.Range("M" & 199 + iterationNum) = Sheet15.Range("L" & 4 + iterationNum) 'QMA Sheet24.Range("N" & 199 + iterationNum) = Sheet15.Range("A7")

Next iterationNum

End Sub

Sub RunTraditional6() Dim pCalcWorksheet As Worksheet Dim pResultWorksheet As Worksheet Dim pInputWorksheet As Worksheet Dim pUserInterfaceWorksheet As Worksheet Dim iSimNumber As Long Dim iNumSimulations As Long Dim iOldCalcalculationSetting As Long Dim pUserWorksheet As Worksheet Dim pTradRunsWorksheet As Worksheet Dim casenum As Long Dim designPoints As Long

Set pCalcWorksheet = ThisWorkbook.Worksheets("Simulation") Set pResultWorksheet = ThisWorkbook.Worksheets("Output") Set pInputWorksheet = ThisWorkbook.Worksheets("Input") Set pUserInterfaceWorksheet = ThisWorkbook.Worksheets("User Interface") Set pTradRunsWorksheet = ThisWorkbook.Worksheets("Traditional Runs") iOldCalcalculationSetting = Application.Calculation iNumSimulations = 7

Application.ScreenUpdating = False

Application.Calculation = xlCalculationManual pResultWorksheet.Columns("B:Q").Clear ThisWorkbook.Worksheets("Simulation").Activate pCalcWorksheet.Cells(8, 2) = "User Defined" 'pCalcWorksheet.Cells(8, 2) = "Model Year" pResultWorksheet.Cells(2, 3) = "Resource Run" pCalcWorksheet.Cells(14, 2) = pUserInterfaceWorksheet.Cells(27, 4) pCalcWorksheet.Cells(15, 2) = pUserInterfaceWorksheet.Cells(28, 4) pCalcWorksheet.Cells(16, 2) = pUserInterfaceWorksheet.Cells(29, 4)pCalcWorksheet.Cells(17, 2) = pUserInterfaceWorksheet.Cells(30, 4) For casenum = 1 To 3 'Run through High UE, Base UE, Low UE scenarios ThisWorkbook.Worksheets("User Interface").Activate pUserInterfaceWorksheet.Cells(18, 17) = casenum ThisWorkbook.Worksheets("Simulation").Activate 'Just for FY 2015 For iSimNumber = 1 To 1 'pCalcWorksheet.Cells(3, 2) = pCalcWorksheet.Cells(9 + iSimNumber, 29) 'Updates the model year Application.Calculate 'Recalculates sheet 'pResultWorksheet.Cells(2, 3 + iSimNumber) = iSimNumber + 2014 'Copies Model Year to output pResultWorksheet.Cells(3, 3 + iSimNumber) = pCalcWorksheet.Cells(11, 5) '4 'Copies NCO to output pResultWorksheet.Cells(4, 3 + iSimNumber) = "N/A" 'Copies Capacity to output pResultWorksheet.Cells(5, 3 + iSimNumber) = pCalcWorksheet.Cells(50, 3) 'Copies unemployment to output pResultWorksheet.Cells(6, 3 + iSimNumber) = pCalcWorksheet.Cells(8, 9) 'Copies total recruiters to output pResultWorksheet.Cells(7, 3 + iSimNumber) = pCalcWorksheet.Cells(8, 10) 'Copies total recruiters cost to output pResultWorksheet.Cells(8, 3 + iSimNumber) = pCalcWorksheet.Cells(9, 10) 'Copies advertising \$ to output pResultWorksheet.Cells(9, 3 + iSimNumber) = pCalcWorksheet.Cells(10, 10) 'Copies EB \$ to output pResultWorksheet.Cells(10, 3 + iSimNumber) = pCalcWorksheet.Cells(11, 10) 'Copies ED \$ to output to output pResultWorksheet.Cells(11, 3 + iSimNumber) = pInputWorksheet.Cells(7, 20 + iSimNumber) 'Copies LRP \$ - a constant to output pResultWorksheet.Cells(12, 3 + iSimNumber) = pCalcWorksheet.Cells(9, 6) 'Copies HSDG% to output

pResultWorksheet.Cells(13, 3 + iSimNumber) = pCalcWorksheet.Cells(11, 6) 'Copies UMG% to output 'pResultWorksheet.Cells(14, 3 + iSimNumber) = WorksheetFunction.Sum(pResultWorksheet.Cells(7, 3 + iSimNumber), pResultWorksheet.Cells(8, 3 + iSimNumber), pResultWorksheet.Cells(9, 3 + iSimNumber), pResultWorksheet.Cells(10, 3 + iSimNumber), pResultWorksheet.Cells(11, 3 + iSimNumber))

ThisWorkbook.Worksheets("Traditional Runs").Activate pTradRunsWorksheet.Cells(7 + casenum, 1 + iSimNumber) = pResultWorksheet.Cells(8, 3 + iSimNumber) 'Also enter Capacity in UE scenarios table ThisWorkbook.Worksheets("Simulation").Activate Next Next

ThisWorkbook.Sheets("Output").Activate Polished 'Formats output 'ResourceChart Application.Calculation = iOldCalcalculationSetting Application.StatusBar = False Application.ScreenUpdating = True ThisWorkbook.Sheets("Output").Activate ActiveSheet.Cells(1, 1).Select

End Sub

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APPENDIX C. PROM-WED USER MANUAL

Planned Resource Optimization Model with Experimental Design (PROM-WED)

USER MANUAL



Table of Contents

- I. What Is PROM-WED
- II. Output Options
- III. Step-by-Step Instructions to Run PROM-WED
- IV. Guidelines for Analysis of PROM-WED Data in JMP
- V. Example Test Cases

NOTICE:

The user is cautioned that PROM-WED has not undergone formal verification and validation testing, and comes without any warranty. Informal testing confirms the outputs from PROM-WED match the output from the legacy PRO model.

I. WHAT IS PROM-WED

PROM-WED embeds the legacy PRO model within a data farming environment. The foundation of PROM-WED's data farming wrapper is the nearly orthogonal Latin hypercube (NOLH). The NOLH design of experiments (DOE) builds experimental designs that efficiently and effectively explore the solution space (Cioppa & Lucas, 2007). This good space-filling capability means that uncertainties and fluctuations in input variables along with multivariable interactions can be adequately investigated (Sanchez & Wan, 2015).

The 33 and 129 design point NOLH designs were used to construct PROM-WED's data farming wrapper. The 33-point NOLH DOE tests each variable at 33 levels and grows data for 33 legacy PRO model runs, whereas the 129-point NOLH DOE tests each variable at 129 levels and grows data for 129 legacy PRO model runs. PROM-WED's graphical user interface (GUI) allows users to easily input a range of values for each input variable into the NOLH DOE worksheet, without need for knowledge or familiarity with data farming or DOE techniques (Sanchez, 2011).

A completed PROM-WED excursion grows a data set for either 33 or 129 data points. Automatically generated sensitivity analysis provides users with a basic risk assessment picture focused on the decision variables using the data grown by PROM-WED. Further insights into variable interactions and effects of input variables can be easily explored using available data analysis software. PROM-WED transforms the legacy PRO model into a resource that N1 can use to gain robust insights into the optimal allocation of recruiting resources.

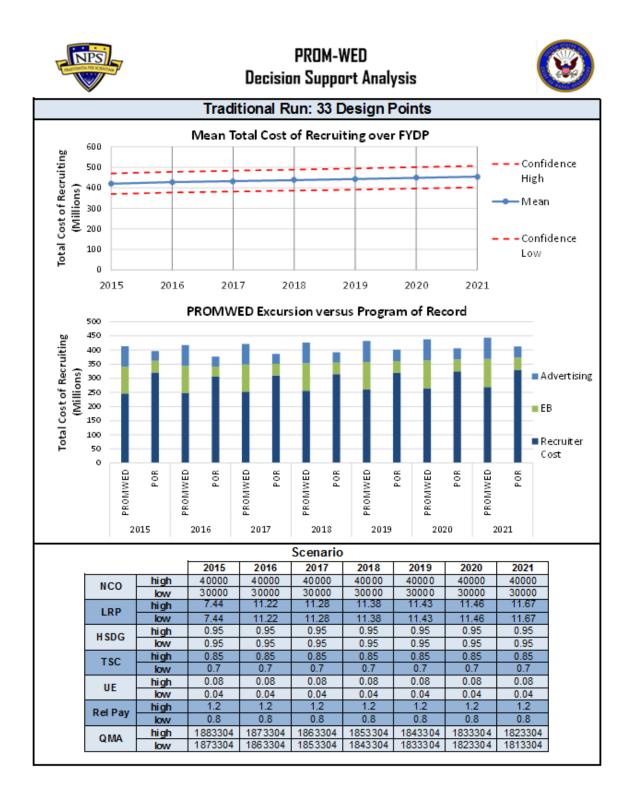
II. OUTPUT OPTIONS

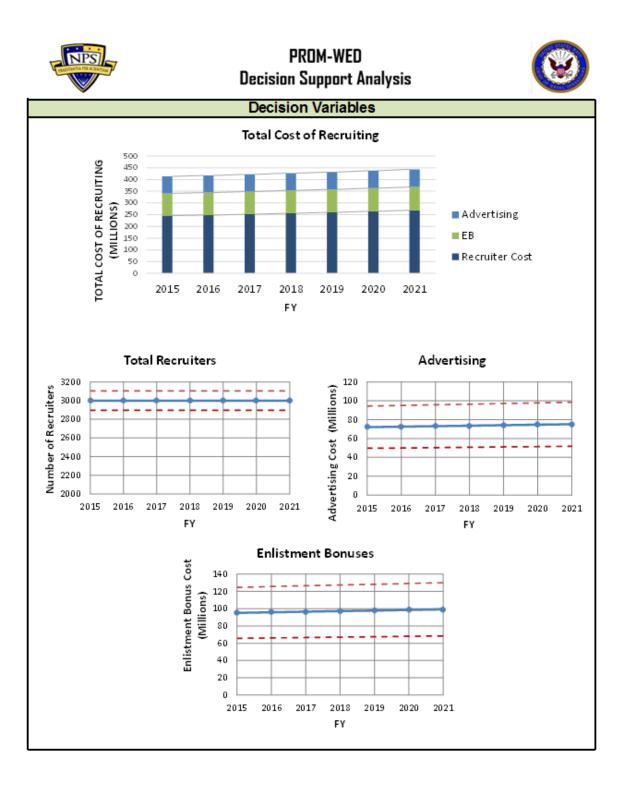
PROM-WED provides users with decision support capabilities to analyze the data grown by each excursion. PROM-WED offers two decision support capabilities: (A) automatically generated analysis, and (B) data generated for further analysis requiring a statistical software package.

A. AUTOMATICALLY GENERATED ANALYSIS

PROM-WED's "Decision Support Analysis" for the traditional run option provides users with a broad understanding of how variability in decision variables, controllable policy changes, and uncontrollable market factors affect the total cost of recruiting. This type of analysis would be appropriate for testing excursions during a time constrained meeting, working group, or whenever basic analysis needs to be generated quickly.

An example of PROM-WED's automatically generated analysis follows.

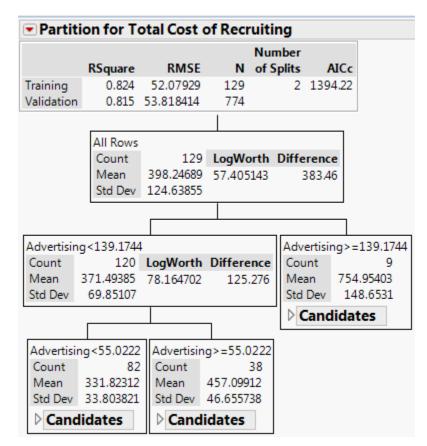




B. JMP ANALYSIS

Analysts will need to use a statistical software package to take full advantage of the data grown by PROM-WED. Therefore, data produced by PROM-WED is designed to be easily uploaded into a software package, such as JMP (JMP Pro, 2015).

The following are examples of insights gained through analysis of PROM-WED data in JMP.



1. Partition Tree

Over 80 percent of variance in the total cost of recruiting is explained by the amount of funds allocated to advertising.

2. Stepwise Regression

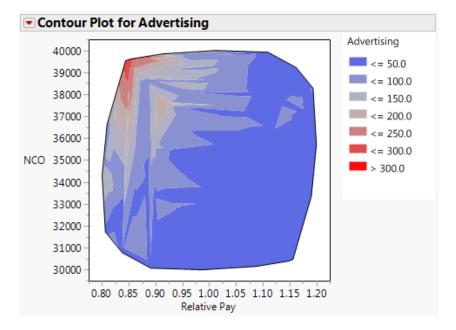
The total cost of recruiting can be formulated into a stepwise regression model:

Prediction Expression

150.980052850998

- + 0.02553596931337 * NCO
- + -24.593679044673 * Unemployment
- + -550.34801858165 * Relative Pay
- + (NCO 35000.0620155039) * ((Relative Pay 1) * -0.1270005027034)
- + (NCO 35000.0620155039) * ((NCO 35000.0620155039) * 0.00000304992539)
- + (Relative Pay 1)* ((Relative Pay 1)* 1882.37625427676)

3. Contour Plots



The contour plot indicates that nearly half of the solution space supports a low advertising budget, represented by the dark blue region. The cost of advertising substantially increases when relative pay favors the civilian sector and the accession mission is high, represented by the red region. Once relative pay exceeds approximately 1.00, changes in the new accession mission have little to no effect on the amount of resources allocated to advertising.

III. STEP-BY-STEP INSTRUCTIONS TO RUN PROM-WED

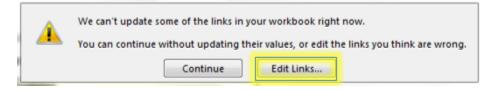
Step 1: Unzip the "PROM-WED.zip" file, and save the "PROM-WED.xlsm" file and "NOLH.xls" file in the same folder. This folder is where the output file generated by PROM-WED will be saved following the PROM-WED excursion.

🕘 – 🔢 🕨 PROM-W	ED • PROM-WED			
Organize 🔻 Burn	New folder			
🔆 Favorites	Name	Date modified	Туре	Size
Recently Changed	NOLH	5/20/2016 2:16 PM	Microsoft Excel 97	1,136 KB
퉬 Public	PROM-WED_v2	1/20/2017 11:55 AM	Microsoft Excel M	2,157 KB
📃 Desktop				
Downloads				
🖳 Recent Places				
🥽 Libraries				
Documents				
Pictures				
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坖 arhogart\$ (\\comfor				
My Web Sites on MS				
📬 Network				

Step 2: Open the PROM-WED file, and ensure the "Enable Content" button is selected.

	Some active of		been disable	ed. Click for	more details	Enable C	Content							
Y41 C D	E	F	G	н	1	J	К	E I	М	N	0	P	0	
N	PSI	F	lanr	ned I	Reso	urce	Optin	niza	atio	n Mo	odel			
PRAESTANTIA	PER SCIENTIAL	7					-					1.8		1
	11/1	5		WIT	псх	perin	nentai	U	esig	п		TER.		Q 25
T		5		WIT	II EX		n ental 4-WED)	U	esig	n		and a		Real Providence
T			_	WIT		(PRON			esig	n				2
		<u> </u>		WI		(PRON	M-WED)		esig	Π			ANAL	
				wit		(PRON Here to Laur	M-WED)		esig	Π				llison Ho

The first time you open PROM-WED, the NOLH.xls file link needs to be updated. To do this, select the "Edit Links..." button.



To update the NOLH.xls file, click on the "Change Source..." button.

Source	Type	Update	Status		Update Values
NOLHals	Worksheet	A	Erron Source not found		Change Source
				1	Open Source
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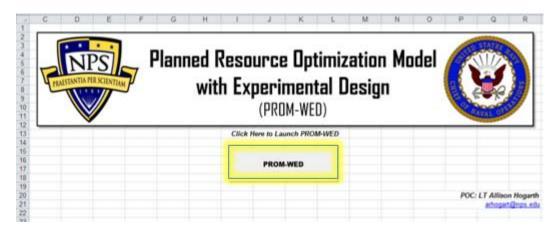
A file search window will pop-up. Navigate to the folder where you saved the files after unzipping them. Select the "NOLH.xls" file, and click on the "OK" button.

PROM-W	ED		earch PROM-WED	Q
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ten a contra	me: NOLH	- Eo	cel Files	•

The "Edit Links" window will pop-up. Once the "NOLH.xls" worksheet's status updates to "OK," click on the "Close" button.

Source	Туре	Update	Status		Update Values
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					Open Source
					Break Link
e [•	Check Status
em:	:\Users\sam_gr	ay\Desktop\	PROM-WED		

Step 3: Open the PROM-WED file, and select the "PROM-WED" button to open the GUI.



Step 4: Select the appropriate starting fiscal year (FY) from the drop-down list. The current version of the legacy PRO model is set at a FY 2015 start.

TRUE				with Exp		timization Mod tal Design ^{D)}	del 😢
Decision	Set Varial	• FY 2015 FY 2016 FY 2017	Sav	red Scenarios: Input V	▼ /alues	Vari	able Set
NCF + C Recruite Advertis EB Market / Relative QMA TSC I-II HSDG Unempk	ers ing (AC En lactors Pay	PY 2018 FY 2019 FY 2020	Pox DV	Select to Test Single Value Select to Test Range of Valuer	Pix Value Set Range Remove	Varied Harket Factors	Fixed Harket Factors
PY .	De: Base Value	sign of Exper		cimal aces		Anał Select Run Type Traditonal Run Capacity Run	ysis Options Design of Experiments 33 Design Points 129 Design Points
						Include output for analysis in Save Scenario Name Run NOLH Run Select to not a DOC ecusio	e Scenario

Step 5: To constrain a decision variable, select it from the list, and click "Fix DV" button.

INPS -		source Op Experimen (PROM-WE	
Start in FY PY 2015	 Saved Scenario 	os: 🔹	
Set Variables		Input Values	Variable Set
Decision Variables		Input values	Fixed Decision Variables
NOF + College First Recruiters	Fix DV		
Advertising (AC Eni. Only)			
EB	Select		
Harket Factors Relative Pay QMA TSC I-IIIA H5DG Unemployment Rate	Add MF Select Renge of		Varied Harket Factors Fixed Harket Factors
Design of Ex Base Low	periments Table High Decimal		1
FY Value Level	Level Places		Analysis Options Select Run Type Design of Experiments
FY15 FY16 FY17 FY17			Traditional Run 33 Design Points 129 Design Points
FY18			Include output for analysis in JMP
FY19			Save Scenario Name Scenario
FY20			Run
FY21			NOLH Run Select to run space-filing. Cancel

The default data from the legacy PRO Model will automatically populate the "Design of Experiments Table."

TRN			Plan		h Exp		timization Mod tal Design D)	
Start in	n [FY 2015 💌		Saved Sce	marios:	•		
	Set Variab Variables	les		_	Input	Values	Vari Fixed Decision Variables	able Set
Recrui	College First tsing (AC Enl.	Only)	Fix D	_	lecruiters	Fix Value		
Market	Factors				Single Value	PIX VAUE		
Relation QMA TSC I-		-	Add M		lelect to Test rige of Valuer	Set Range	Varied Market Factors	Fixed Harket Factors
HSDG	koyment Rate				_	Remove		
	De	sign of Expe	riments Ta	ble				
FY	Base Value	Low	High Level	Decimal Places				ysis Options
FY15	3913	3913	3913	0			Select Run Type Traditional Run	33 Design of Experiments
FY16	3685	3685	3685	0			Capacity Run	129 Design Points
FY17	3685	3685	3685	0				
FY18	3685	3685	3685	0			T Include output for analysis in	340
FY19	3685	3685	3685	0			Save Scenario Name	e Scenario
FY20	3685	3685	3685	0			Run	
FY21	3685	3685	3685	0			NOLH Run Select to run o DOE excursion	

Step 6: Input the range of values for the decision variable in the "Design of Experiments Table." Input the low value of the range in the "Low Level" text box for each FY, and the high value of the range in the "High Level" text box for each FY. In this example, the number of recruiters is tested from 2,500 to 3,500 for each FY.

Each year can be tested using different ranges. For example, to represent a smaller recruiter force in FY 2021, the range could be inputted as 2,000 to 2,700.

If you want to constrain the decision variable at the default value populated by the legacy PRO model, select the "Fix Value" button. By selecting "Fix Value," the default values for the decision variable in the "Design of Experiments Table" are deposited into the NOLH worksheet for each FY. This decision variable is now moved to the "Fixed Decision Variables" list, and the "Design of Experiments Table" is cleared. (If this is your course of action, continue to Step 8.)

If you want to constrain the decision variable at one number that is different than the default value populated by the legacy PRO model, the same number has to be inputted into the "Low Level" and "High Level" text boxes. For example, if you want to constrain the number of recruiters in FY 2021 to 2700, then you would enter 2700 in both the "Low Level," and "High Level" text boxes.

TRUET			Plar				timizatio tal Desig			
Start in FY	- I	FY 2015 +]	Saved Se	enarios:	•				
Si Decision V	et Variat aviables	les			Input	Values	Fixed Decision V	Variab	le Set	
NOF + Co Recruiter Advertisin			Fix D	v I	Recruiters		Foxed Decision V	anabics		_
EB	ctors				Select to Test Single Value	Pix Value				
Relative P QMA TSC I-IIIA HSDG Unemploy		Î	Add	ę į	Select to Test large of Values	Set Range Remove	Varied Harket F	actors	Fixed Market Factor	5
(oriented)		sign of Expe	riments Tr	able	1					
FY	Base Value	Low	High Level	Decima Places					is Options	
FY15	3913	2500	3500	0			Select Ru Traditional Run	n Type	Design of Exper 33 Design Points	iments
FY16	3685	2500	3500	0			Capacity Run		129 Design Points	
FY17	3685	2500	3500	0						
FY18	3685	2500	3500	0			T Include output	for analysis in 3	P	
FY19	3685	2500	3500	0			C Save Scenario	Name 5	icenario	_
FY20	3685	2500	3500	0			Run			
FY21	3685	2500	3500	0			NOLH Run	Select to run spec DOE excursions	y-filing.	Cancel

Step 7: Once the "Design of Experiments Table" is fully populated with the low and high levels for each FY, select the decision variable from the "Input Values" box, and click on the "Set Range" button.

FRAL			Plar		vith Exp	•	ti mizatio t al Desig D)		:I 🤇	
Start in	FY	FY 2015 💌	1	Save	Scenarios:	-				
Decision	Set Variat				Input	Values		Variable	e Set	
NCF +	College First		Fix D	w I	Recruiters		Fixed Decision	ariables		
Adverti E8	sing (AC Eni.	. Only)		_	Select to Test	Fix Value				
Market	Factors				Single Value	Fix value				
QMA TSC I-I		-	Add N	Æ	Select to Test Range of Values	Set Range	Varied Market I	Factors	Fixed Mark	et Factors
HSDG	oyment Rate					Remove				
		sign of Expe					1			
FY	Base Value	Low	High Level	Deci					Options	
FY15	3913	2500	3500	0			Select Ru Traditional Run	in Type	33 Design	of Experiments
FY16	3685	2500	3500	0			Capacity Run		129 Design	
FY17	3685	2500	3500	0						
FY18	3685	2500	3500	0			T Include output	for analysis in JM	>	
FY19	3685	2500	3500	0	_		Save Scenario	Name So	enario	
FY20	3685	2500	3500	0			Run			
FY21	3685	2500	3500	0	-		NOLH Run	Select to run space DOE excursions	-filing.	Cancel

By selecting "Set Range," the low and high values entered for this decision variable in the "Design of Experiments Table" are deposited into the NOLH worksheet for each FY. This decision variable is now moved to the "Fixed Decision Variables" list, and the "Design of Experiments Table" is cleared.

PRACTINITA RE SCIEVILAR		Resource Op h Experimen (PROM-WE	
Start in FY PY 2015 -	Saved Sce	narios: 💌	
Set Variables Decision Variables NCF + College First Recourters Advertising (AC Enl. Only) EB Market Factors		Input Values	Variable Set Fixed Decision Variables Recruiters
Relative Pay QMA TSC I-IIIA HSDG Unemployment Rate	Ra	elect to Test ge of Values Remove	Varied Market Factors Fixed Market Factors
Base Low EV Value Level	High Decimal Level Places		Analysis Options
FY Value Level FY15 FY16 FY16 FY17 FY17 FY17 FY17 FY17 FY17 FY17 FY17			Select Run Type Design of Experiments Traditional Run 33 Design Points Capacity Run 129 Design Points
FY18			Include output for analysis in JMP
FY19 FY20			Save Scenario Name Scenario Run
FY21			NOLH Run Select to run space-filling. DOE excursions Cancel

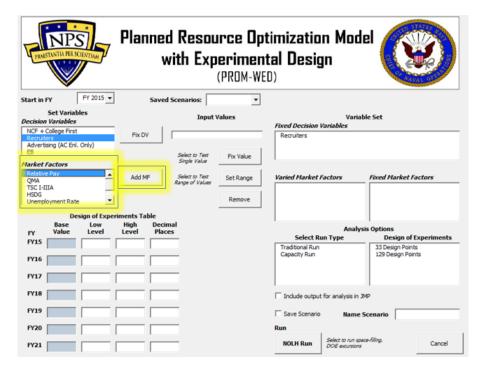
Step 8: Follow Steps 5–7 to fix any other decision variables.

Reminders:

- If you constrain a decision variable to a number other than the default values populated from the legacy PRO model, as mentioned earlier enter the same number into the low and high level text boxes, and select the "Set Range" button when complete.
- Since the PRO model solves an optimization problem, ensure that at least one of the following decision variables: Recruiters, Advertising or Enlistment Bonus (EB) remain in a "float" status. In this example, only the number of recruiters are fixed.

Step 9: Once all decision variables that need to be fixed are fixed, gears shift to the market factors. The "Market Factors" list includes all market factors (relative pay, QMA and unemployment rate) and policy factors (percentage of high quality recruits (TSC I-IIIA), percentage of recruits with a high school diploma (HSDG), and NCO). Each market factor, from relative pay to NCO, must either be fixed at one value, or a range of values needs to be entered.

Similar to how decision variables are fixed, select "Relative Pay" from the list of market factors, and select the "Add MF" button.



The default data from the legacy PRO Model automatically populates in the "Design of Experiments Table."

PANE		CUNTING	1 101		th Exp	•	timizatio tal Desig D)			
tart in F	Y	FY 2015 •]	Saved Sc	enarios:	•				
ecision	Set Varial Variables	-			Input	Values	Fixed Decision	Contraction of the second states	ble Set	
Adverts EB	sing (AC Eni Factors I Pay		Fix D	- ·	Relative Pay Select to Test Single Value Select to Test large of Values	Fix Value Set Range	Recruiters Varied Market	Factors	Fixed Market	Factors
HSDG	oyment Rati		í		-	Remove				
FY	Base Value	Low Low	High Level	ble Decimal Places			Select R		is Options	of Experiments
PY15 PY16 PY17	0.4	0.4	0.4	6			Traditional Run Capacity Run	an type	33 Design Po 129 Design P	ints
FY18	0.4	0.4	0.4	6			Include output	t for analysis in J	MP	
FY19	0.4	0.4	0.4	6			F Save Scenario	Name 9	Scenario	
FY21	0.4	0.4	0.4	6			NOLH Run	Select to run spa DOE excursions	ce-filing.	Cancel

Step 10: Input the range values for the market factor in the "Design of Experiments Table." Input the low value of the range in the "Low Level" text box for each FY, and the high value of the range in the "High Level" text box for each FY.

In this example, the relative pay is tested from 0.8 to 1.2 for each FY. Clicking the "Set Range" button deposits the low and high values entered for this market factor into the NOLH worksheet for each FY.

RAETAVILA PER SCIEN	TIM	Plan			-	tal Desig	n Model jn	
Start in FY	2015 👻		Saved Sc	enarios:	-			
Set Variables Decision Variables NCF + College First Regulters Advertising (AC Enl. On	_	Fix DV		Input Relative Pay	Values	Fixed Decision N Recruiters	Variable Set Variables	
EB Market Factors Relative Pay QMA TSC 1-IIIA HSDG Unemployment Rate	▲ ▼	Add M	F	Select to Test Single Value Select to Test ange of Values	Fix Value Set Range Remove	Varied Market I	Factors Fixed P	larket Factors
		iments Tal						
Base FY Value	Low Level	High Level	Decimal Places				Analysis Option	5
FY15 0.4 (0.8 [0.8 [0.8 [1.2 1.2 1.2	6			Select Ru Traditional Run Capacity Run	33 De	esign of Experiments sign Points esign Points
	0.8	1.2	6				for analysis in JMP	
	0.8	1.2	6			Save Scenario	Name Scenario	
FY21 0.4	0.8	1.2	6			NOLH Run	Select to run space-filling, DOE excursions	Cancel

This market factor is now moved to the "Varied Market Factors" list, and the "Design of Experiments Table" is cleared.

PARETANIA PER SCIENCIAL		Resource Op h Experimen (PROM-WE	-	
Start in FY FY 2015 -	Saved Scer	arios: 🔹		
Set Variables Decision Variables NCF + College First	Fix DV	Input Values	Variable Fixed Decision Variables	Set
Advertising (AC Enl. Only) EB Market Factors	54	lact to Test Ingle Value	Reduces	
Relative Pay ▲ QMA TSC I-IIIA HSDG Unemployment Rate		lect to Test ge of Values Remove	Varied Market Factors	ixed Market Factors
Design of Expe Base Low	riments Table High Decimal			
FY Value Level	Level Places		Analysis (Select Run Type	Design of Experiments
FY15 FY16 FY17 FY17			Traditional Run Capacity Run	33 Design Points 129 Design Points
FY18			Include output for analysis in JMP	
FY19			Save Scenario Name Sce	nario
FY20			Run	
FY21			NOLH Run Select to run space-fi DOE excursions	Cancel

Step 11: Work through each "Market Factor" in the list, from "Relative Pay" to "NCO" following Steps 9–10.

Note that each year can be tested using a different range of values for the market factors. For example, an annual decrease of 10,000 QMA can be entered as shown in the figure below.

	Des	ign of Expe	riments Tal	ble
FY	Base Value	Low Level	High Level	Decimal Places
FY15	1883304	1873304	1883304	0
FY16	1883304	1863304	1873304	0
FY17	1883304	1853304	1863304	0
FY18	1883304	1843304	1853304	0
FY19	1883304	1833304	1843304	0
FY20	1883304	1823304	1833304	0
FY21	1883304	1813304	1823304	0

If you want to constrain the market factor at one number different than what is populated by the legacy PRO model, the same number has to be inputted into the "Low Level" and "High Level" text boxes. Then select the "Set Range" button.

To constrain the market factor at the value automatically populated in the "Design of Experiments Table," select the market factor from the "Input Values" box, and click on the "Fix Value" button.

PRAES	NPS TANTIA PER SC	NEW TRAN	Plar			u rce Opt D eriment (PROM-WEI	al Desig			
Start in F	γr	FY 2015 👻		Saved Sci	narios:	-				
Decision NCF + C Recruite	sing (AC Enl.		Fix D		Input ISDG Felect to Test Single Value	Values Fix Value	Fixed Decision V	Variable S / <i>ariables</i>	et	
Relative QMA TSC I-II HSDG	: Pay IA oyment Rate	sign of Exper	Add M	<u> </u>	ielect to Test Inge of Values	Set Range Remove	Varied Market I Relative Pay QMA TSC I-IIIA	Factors Fi	xed Market Fact	ors
	Base Value	Low	High	Decimal				Analysis O	ptions	
FY FY15 FY16 FY17	0.95 0.95 0.95	0.95	0.95 0.95 0.95	2 2 2			Select Ru Traditional Run Capacity Run	in Type	Design of Exp 33 Design Points 129 Design Points	eriments
FY18 FY19	0.95	0.95	0.95	2			Include output Save Scenario	for analysis in JMP Name Scen	ario	
FY20 FY21	0.95	0.95	0.95	2			Run NOLH Run	Select to run space-filli DOE excursions	hg.	Cancel

Step 12: Work through all seven market factors until they are all accounted for. A market factor is accounted for once it appears in either the "Varied Market Factors," or "Fixed Market Factors" lists.

PRESIDENTIA PER SCIENTIAN		esource Op 1 Experimen (PROM-WE		del 🛞
Start in FY FY 2015 -	Saved Scen	arios: 🔹		
Set Variables Decision Variables		Input Values	Van Fixed Decision Variables	iable Set
NCF + College First Recruiters Advertising (AC Enl. Only) EB	Fix DV		Recruiters	
Market Factors		ect to Test Fix Value ogle Value		
TSC I-IIIA HSDG Unemployment Rate		lect to Test Set Range	Varied Market Factors Relative Pay	Fixed Market Factors
LRP NCO (50% BoY DEP)		Remove	QMA TSC I-IIIA Unemployment Rate	LRP
Design of Exper Base Low	riments Table High Decimal		NCO (50% Boy DEP)	
FY Value Level	Level Places		Ana Select Run Type	lysis Options Design of Experiments
FY15			Traditional Run Capacity Run	33 Design Points 129 Design Points
FY16				
FY18			I Include output for analysis	n JMP
FY19			Save Scenario Nam	e Scenario
FY20			Run	
FY21			NOLH Run Select to run DOE excursio	

Step 13: Select "Traditional Run" under "Select Run Type." (Currently, only the Traditional Run option is operational).

Automatically Generated Decision Support:

The "33 Design Points" option is well suited for the automatically generated decision support analysis. The "129 Design Points" option can also be used, but it will take additional time to run (approximately 10 minutes versus 2–3 minutes). The "129 Design Points" option grows more data, resulting in a narrower 95% confidence interval.

Analysis in JMP:

The "129 Design Points" option is intended to be used for further analysis in a commercial statistical software package, such as JMP.

PRETAVILA PER ACENTIAN	Planned Reso with Exp	-	tal Design	
Start in FY FY 2015 -	Saved Scenarios:	•		
Set Variables Decision Variables	Input	Values	Varia Fixed Decision Variables	ble Set
NCF + College First Recruiters Advertising (AC Enl. Only) EB	Fix DV Select to Test	Fix Value	Recruiters	
Market Factors	Single Value	Fix value	1	
TSC I-IIIA HSDG Unemployment Rate LRP NCO (50% Boy DEP)	Add MF Select to Text Range of Values	Set Range Remove	Varied Harket Factors Relative Pay QMA TSC I-IIIA Unemployment Rate NCO (50% BoY DEP)	Fixed Market Factors HSDG LRP
Base Low FY Value Level	High Decimal Level Places		Analy	sis Options
FY15			Select Run Type	Design of Experiments
FY16			Traditional Run Capacity Run	33 Design Points 129 Design Points
FY18			Include output for analysis in J	MP
FY19			Save Scenario Name	Scenario
FY20			Run	
FY21			NOLH Run Select to run spu DOE excursions	ce-filing. Cancel

Step 14: To save PROM-WED output to a separate .xls file for analysis in JMP, select the "Include output for analysis in JMP" box. This will save the PROM-WED output as a .xls file in the same folder that the PROM-WED model was saved in.

CRASTINUE PERSONAL	Planned Reso with Ex		tal Design	del 🛞
Start in FY D15 -	Saved Scenarios:	•		
Set Variables Decision Variables	Inpu	t Values	Va Fixed Decision Variables	riable Set
NCF + College First Recruiters Advertising (AC Enl. Only) EB	Fix DV Select to Test	Fix Value	Recruiters	
Market Factors	Single Value			
TSC I-IIIA HSDG	Add MF Select to Test Range of Values	Set Range	Varied Market Factors	Fixed Market Factors
Unemployment Rate LRP NCO (50% Boy DEP)		Remove	Relative Pay QMA TSC I-IIIA Unemployment Rate NCO (50% BoY DEP)	HSDG LRP
Design of Exper Base Low	High Decimal		, , , , , , , , , , , , , , , , , , , ,	had a free
FY Value Level	Level Places		Select Run Type	lysis Options Design of Experiments
FY15			Traditional Run	33 Design Points
FY16			Capacity Run	129 Design Points
FY17				
FY18			Include output for analysis	in JMP
FY19			Save Scenario Nan	ne Scenario
FY20			Run	
FY21			NOLH Run Select to run DOE excursi	space-filing. Cancel

Step 15: Once the run options are set, select the "NOLH Run" button. A message will pop-up providing an estimated wait time for the PROM-WED excursion. Click "OK."

		(PROM-	WED)	ALL DESCRIPTION OF THE OWNER
sart in FY FY 2015 Set Variables ecision Variables	Save	d Scenarios: Input Values	Fixed Decision Variables	Variable Set
ICF + College First Lecruiters	Fix DV	[Recruiters	
B Microsoft Excel	_	Marco Inc. No. of Co.	×	
complete. Thank		nutes to run. Analysis will appea ence and have a fine Navy day!	ar when run is Rate r DEP)	Fixed Harket Factors QMA TSC 1-IIIA HSDG
complete. Thank:			CK	QMA TSCI-IIIA HSDG LRP Analysis Options
complete. Thank			OK Rate	QMA TSC 1-IIIA HSOG URP Analysis Options Design of Experiment
Y 15			CK	QMA TSCI-IIIA HSDG LRP
vite vite vite vite vite vite vite vite			OK Itadiconal Run	QMA TSC 1-111A HSDG URP Malysis Options Design of Experiment 330 Cearson Fonts 129 Design Points
PY PY PY PY PY PY PY PY PY PY			OK Un Type Tridbond Run Cepacity Run	QMA TSC 1-111A HSOG LRP Innalysis Options Design of Experiment 33 Design Points 129 Design Points sis in JMP
			Capacity Run	QMA TSC 1-111A HSOG LRP Innalysis Options Design of Experiment 33 Design Rons 129 Design Points sis in JMP

Step 16: When the PROM-WED excursion is complete, the automatically generated decision support analysis will appear (this is true for both the 33 and 129 point designs). If you selected the option to output PROM-WED data for analysis in JMP, the .xls file named "PROMWED_Output129.xls" will appear in the folder that your PROM-WED model is saved in.

Der 🍌 🕨 PROM-	WED			✓ 4→ Search PRON	M-WED	
Organize 🔻 Include	in library 🔹 Share with 🔹 Burn	New folder			≣ • 🗖	
🔆 Favorites	Name	Date modified	Туре	Size	10 M 24/144	
E Desktop	NOLH	2/2/2017 11:24 AM	Microsoft Excel 97	1,136 KB		
🐞 Downloads	PROM-WED	2/2/2017 11:24 AM	Microsoft Excel M	2,186 KB		
Secent Places	PROMWED_Output129	2/2/2017 11:45 AM	Microsoft Excel W	182 KB		

Please be aware that each 129 design point output file will be named "PROMWED_Output129.xls." It is recommended that you rename the file before running another PROM-WED excursion.

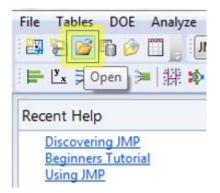
IV. GUIDELINES FOR ANALYSIS OF PROM-WED DATA IN JMP

Using JMP Pro 12, the following section provides a tutorial on analysis techniques for PROM-WED output. Steps 1–5 explain how to upload and prepare the data for analysis in JMP, followed by guidance on how to conduct various analysis techniques.

Analysis Techniques:

- A. Oneway Analysis of Total Cost of Recruiting by FY
- B. Explore Outliers from the Oneway Analysis Graph
- C. Select one FY to Analyze
- D. Distribution
- E. Partition Trees
- F. Stepwise Regression Model
- G. Scatterplot Matrix
- H. Contour Plot

Step 1: To load the PROM-WED data into JMP, select the folder icon.



Step 2: Select the output data of interest, select the "Best Guess" option, and click "Open."

Organize 🔻 New f	older				🗋 🔞
	^ N	ame	Dat	te modified	Туре
Favorites	Ŕ	NOLH	2/2	/2017 11:24 AM	Microsoft Excel 97.
🌽 Data	0	PROM-WED	2/2	/2017 11:46 AM	Microsoft Excel M.
	0	PROMWED_Output129	2/2	/2017 11:45 AM	Microsoft Excel W.
Y Favorites	E				
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E Pictures					
Videos			m		
Alway Excel Row 1		e Best Guess			
		Never			
				All JMP Files	
Fil	le name:	PROMWED_Output129		Par style titles	

Step 3: Select the "Import" button.

	Run #	FY	Total Cost of Recruiting	Advertising	EB	E 1	Select sheets to open	Custom
1	1	2015	327.1265	35.7344	47.1694		JMP_129DesPts	
2	2	2015	377.1404	55.9153	73.8082		Select a	
3	3	2015	410.8494	85.6254	113.0255		Jelect	
4	4	2015	283.2184	20.127	26.5676			
5	5	2015	359.4841	43.8919	57.9373			
6	6	2015	467.9692	85.7103	113.1376			
7	7	2015	316.5387	18.2144	24.043	Ψ.		
8	4	111						
Worksheet co	ntains colu	umn hea	ders 🖉 🛛	iew Pane Refre Ipdate settings late now	1.1	nge		
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Worksheet co 1 Colur 1 Num 2 Data 1 Data	ntains colu nn header: ber of row: starts on ro starts on c	umn hea s start on s with co ow 👍 olumn	ders row	Ipdate settings late now	1.1	nge		
Worksheet co 1 Colur 1 Colur 2 Data 1 Data Concatenate w	ntains colu nn header: ber of row: starts on ro starts on c orksheets o	umn hea s start on s with co ow olumn and try to	ders row A lumn headers A I I I I I I I I I I I I I	Ipdate settings late now] how all rows	1.1	nge		
Worksheet co 1 Colur 1 Colur 2 Data 1 Data Concatenate w	ntains colu mn header: ber of row: starts on ro starts on c orksheets a mn with w	umn hea s start on s with co ow olumn and try to	ders row A lumn headers A match columns	Ipdate settings late now] how all rows	1.1	nge		

File Edit Tables Rows Cols DOE Analyze Graph Tools View Window Help								
JMP_129DesPts Source		Run #	FY	Total Cost of Recruiting	Advertising	EB	Education Incentive	Tot
	1	1	2015	327.1265	35.7344	47.1694	()
	2	2	2015	377.1404	55.9153	73.8082	()
 Columns (15/0) 	3	3	2015	410.8494	85.6254	113.0255	()
A Run #	4	4	2015	283.2184	20.127	26.5676	()
🖌 FY	5	5	2015	359.4841	43.8919	57.9373	()
Total Cost of Recruiting	6	6	2015	467.9692	85.7103	113.1376	()
Advertising	7	7	2015	316.5387	18.2144	24.043	()
EB	8	8	2015	464,2046	77,1682	101.862	()
Education Incentive Total Recruiters	9	9	2015	404.0421	73.583	97.1295	(
Recruiter Cost	10	10	2015	471,4698	104.0235	137.311		
NCO	11	11	2015	320.903	30.0158	39.6208		
LRP	12	12	2015	401.3847	72.72	95,9904		
🔺 HSDG	13	12	2015	316.4949	11.3114	14,9311		
TSC I-IIIA	13	13	2015	566.1871	120.0318	158.4419	(
Unemployment	14	14	2015	310.9625	8.0795	10.6649	(
▲ Relative Pay ▲ QMA								
	16	16	2015	489.4982	84.7874	111.9194	(
 Rows 	17	17	2015	450.3778	95.4969	126.056	(
All rows 903	18	18	2015	422.3013	81.1709	107.1456	(
Selected 0 Excluded 0	19	19	2015	313.7766	33.8635	44.6998	(
Hidden 0	20	20	2015	332.7022	38.4201	50.7146	(
abelled 0	21	21	2015	382.5251	44.468	58.6978	()

Step 4: Change the FY column from "continuous" to "nominal" data, by rightclicking on the blue triangle next to "FY," and select "nominal" from the dropdown menu.

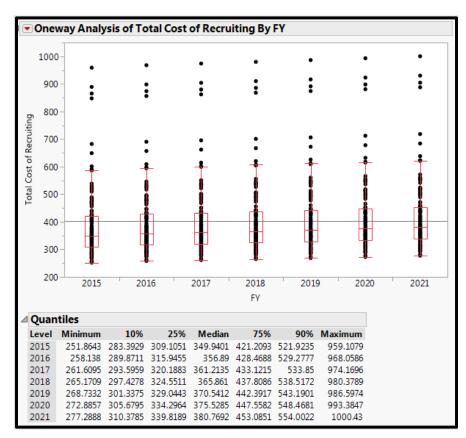
JMP_129DesPts			
 Source 		Run #	FY
	1	1	2015
	2	2 3 4 5 6 7 8 9 10 11 11	2015
 Columns (15/1) 	3	3	2015
A Run #	4	4	2015
	5	5	2015
Continuous	6	6	2015
Ordinal	7	7	2015
Nominal	8	8	2015
Nominal	9	9	2015
Recruiter Cost	10	10	2015
A NCO	11	11	2015
LRP HSDG	12	12	2015
TSC I-IIIA	13	13	2015
Unemployment	14	14	2015
A Relative Pay	15	15	2015
QMA QMA	16	16	2015
Rows	17	17	2015
All rows 90	3 18	18	2015
	19	19	2015
	20	20	2015
	21	21	2015
Labelled			

The blue triangle next to FY will change to a red bar chart icon when JMP changes its classification to nominal data.

Columns (15/1)
🔏 Run #
d. EY
Total Cost of Recruiting
🚄 Advertising
🚄 EB
Education Incentive
Total Recruiters
A Recruiter Cost
🔺 NCO
🚄 LRP
🔺 HSDG
A TSC I-IIIA
🚄 Unemployment
🚄 Relative Pay
🚄 QMA

The data is now ready to be analyzed.

A. ONEWAY ANALYSIS OF TOTAL COST OF RECRUITING BY FY



Step 1: To create an oneway analysis of total cost of recruiting by FY graph, select "Analyze" from the ribbon, and select "Fit Y by X."

F	Distribution					
l ^y x ⊠	Fit Y by X Matched Pairs	variables	. Creates a O	s between two neway, Bivariate,	lucation centive	Tot
7	Matched Pairs		ency, or Logi	stic analysis and modeling	0	
	Tabulate	type.	Tthe context	and modeling	0	
		10.8494	60.0204	113.0255	0	
)	Fit Model	183.2184	20.127	26.5676	0	
	Modeling	59.4841	43.8919	57.9373	0	
	Multivariate Methods	67.9692	85.7103	113.1376	0	
	Multivariate Methods	16.5387	18.2144	24.043	0	
	Quality and Process	64.2046	77.1682	101.862	0	
	Reliability and Survival	04.0421	73.583	97.1295	0	
	Reliability and Survival	71.4698	104.0235	137.311	0	
	Consumer Research	320.903	30.0158	39.6208	0	
-17	12 2013	 401.3847	72.72	95.9904	0	

Step 2: Select "Total Cost of Recruiting" from the list of columns, and select the "Y, Response" button.

Nistribution of Y for each X. Modeling types d	etermine analysis.		
Select Columns	Cast Selected	Columns into Roles —	Action
15 Columns	Y, Response	required	OK
ARun #		optional	Cance
Total Cost of Recruiting			_
deB	X, Factor	required	Remov
Education Incentive		optional	Recall
Total Recruiters			Help
ARecruiter Cost	Block	optional	
	Weight	optional numeric	
TSC I-IIIA	Freq	optional numeric	
Unemployment Relative Pay	Ву	optional	
4QMA			_1
Bivaniate Oneway			

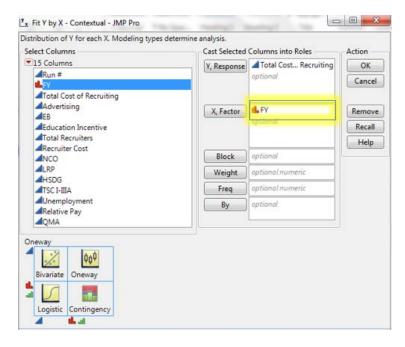
"Total Cost of Recruiting" should now appear in the "Y, Response" box.

Distribution of Y for each X. Modeling type	es determine analysis.		
Select Columns	Cast Selected	Columns into Roles	Action -
15 Columns	Y, Response	Total Cost Recruiting	OK
ARun #		optional	Cancel
Total Cost of Recruiting			Construction
Advertising	X. Factor	required	Remove
EB Education Incentive	(rucios	optional	Recall
Total Recruiters			
ARecruiter Cost			Help
M NCO	Block	optional	
	Weight	optional numeric	
TSC I-IIIA	Freq	optional numeric	
4Unemployment	By	optional	
ARelative Pay AQMA			
\$00 ⁰			
Bivariate Oneway			
a 🗾 🔚			
Logistic Contingency			

y Fit Y by X - Contextual - JMP Pro Distribution of Y for each X. Modeling types determine analysis. Select Columns Cast Selected Columns into Roles Action ■15 Columns Y, Response Total Cost... Recruiting OK optional Cancel 15 Advertising required X Factor Remove **AEB** Recall Education Incentive **A**Total Recruiters Help ARecruiter Cost Block optional **A**NCO **ALRP** Weight optional numeric HSDG Freq optional numeric TSC I-IIIA **d**Unemployment By optional ARelative Pay -QMA 000 Ŀ Bivariate Oneway d. -1--Logistic Contingency 1.4 4

Step 3: Select "FY" from the list of columns, and select the "X, Factor" button.

"FY" should now appear in the "X, Factor" box.



Step 4: Click-on the "OK" button to generate the graph of FY by total cost of recruiting.

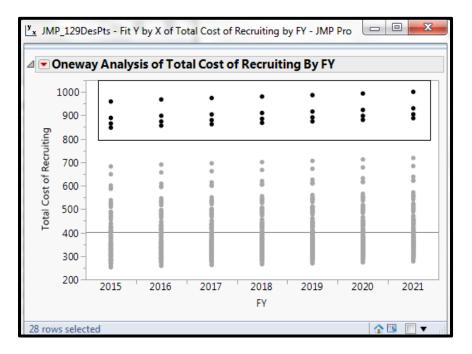
Distribution of Y for each X. Modeling types	s determine analysis.		
Select Columns	Cast Selected	Columns into Roles	Action
15 Columns	Y, Response	Total Cost Recruiting	OK
ARun #	(Charles Provide)	optional	Cancel
d. FY		e	Cancel
Total Cost of Recruiting			
Advertising EB	X, Factor	🛃 FY	Remove
Fducation Incentive		optional	Recall
Total Recruiters			
ARecruiter Cost			Help
⊿ NCO	Block	optional	
LRP	Weight	optional numeric	
HSDG	Freq	optional numeric	
d Unemployment	By	optional	
ARelative Pay			
4QMA		·	
Oneway			
000			
Bivariate Oneway			
Logistic Contingency			
cogistic contailigency			

Step 5: To add boxplots on the data for each FY, select the red triangle in the upper left hand corner of the graph. From the drop-down menu, select "Quantiles."

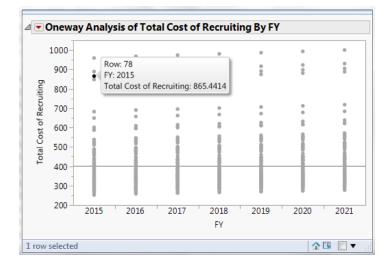
x JMP_129DesPts - Fit Y by X of Total Cost of Recruiting by FY - JMP Pro

Quantiles		- Shows or hides	a quantile report
Means/Anova		· · ·	•
Means and Std Dev			:
Analysis of Means Methods	+	: :	:
Compare Means	•		

B. EXPLORE OUTLIERS FROM THE ONEWAY ANALYSIS GRAPH



Step 1: Hover your mouse over a data point of interest to retrieve information regarding that point.



Clicking on the data point on the graph will highlight it within the greater data set. Understanding the input variables can help explain why the total cost of recruiting was unusually high for this data point.

	Run	EV	Total Cost	Adverticing	60	Education	Total	Recruiter	NCO	100	HEDG	TSC	Unamployment	Relative	OMA			
76	78					0							7					
75						0				7.44	0.95		7.1					
			959.1079	321.1317	423.8939	0		206.6423	39688	7.44	0.95	0.7			1883304			
1				25.0296				206.0689	30234	7.44	0.95	0.7	5		1883304			
			324.3377	20.1992	26.663			270.0355		7.44	0.05	0.7	73	0.0625	1883304		_	
	83	2015	332.0137	25.7319	33.9662	0	3234	264.8756	38516	Ľ	JMP_12	9DesP	ts - Fit Y by X of To	otal Cost of	Recruiting b	y FY - JMP F	ro 😐	• • X
	84	2015	420.0764	64.2196	84.7698	0	3219	263.647	33203	1e	_	-						
	85	2015	375.048	48.4117	63.9034	0	3117	255.2929	36563	⊿	• One	way	Analysis of Tot	tal Cost o	f Recruiti	ng By FY		
86	86	2015	406.6708	77.4697	102.26	0	2680	219.5011	36953	11 °						• •		
87	87	2015	287.67	20.1041	26.5374	0	2852	233.5885	31406		100	0-					٠	
88	88	2015	889.4207	283.8923	374.7378	0	2727	223.3506	39453	н.	90	0-1	Row: 78			:	:	*
89	89	2015	284.4178	30.0346	39.6457	0	2531	207.2975	31875	11						8	•	
90	90	2015	385.3536	55.325	73.029	0	3047	249.5596	35313	н.	·듩 80	0	Total Cost of P	Kecruiting: 8	65.4414			
91	91	2015	309.2005	22.7828	30.0733	0	3039	248.9044	36172	11	5 70	0-					٠	:
92	92	2015	405.8733	57.8151	76.3159	0	3227	264.3023	33984	н.	10		: :		:		:	
93	93	2015	352.9529	38.3231	50.5865	0	3133	256.6033	37188	н.	16 60	0-	+ +					i
94	94	2015	509.7736	120.0042	158.4055	0	2734	223.9239	40000	1	50 SO	0-	1	- 1		- i -	- 1	- i -
95	95	2015	279.5667	28.7556	37.9574	0	2508	205.4137	32578	н.	Tota		1 1	- 1-	- 1	1	1	
96	96	2015	847.7716	263.7513	348.1517	0	2789	228.4286	39609	1	40	0						
97	97	2015	270.0264	22.7017	29.9663	0	2563	209.9184	33359	н.	30	0-		_	_			
	98	2015	301.1586	14.3387	18.9271	0	3180	260.4528	30938	1								
99	99	2015	368.3449	37.2262	49.1385	0	3352	274.5402	36250	н.	20	0 2	015 2016	2017	2018	2019	2020	2021
100	100	2015	328.4267	16.7369	22.0926	0	3445	282.1572	30625	н.					FY			
101	101	2015	601.0501	138.095	182,2854	-0	3336	273.2297	38906		row sele							B
	• 77 77 79 60 81 82 83 64 85 66 66 68 89 90 90 91 94 95 97 98 97 99 94 95 97 98 98 99 96 97 98 98 98 99 9100	Image: 200 minipage Image: 200 minipage 70 77 70 77 70 79 80 80 82 82 84 84 85 85 86 86 87 87 88 88 89 99 90 90 91 92 93 92 94 95 96 96 97 97 98 98 99 96 99 99 90 100	# P 7 7 2015 79 79 2015 80 80.0 2015 81 81 2015 82 82 2015 83 82 2015 84 84 2015 86 86 2015 86 86 2015 87 87 2015 88 2015 90 2015 91 91 2015 90 90 91 91 2015 93 93 2015 93 94 204 2015 94 94 2015 94 94 2015 95 2015 95 2015 96 96 96 96 96 96 96 96 90 2015 99 99 2015 100 100 2015 100 100 2015	# FV of Recruking 7 7 2015 665.444 79 79 2015 2657.214 60 60 2015 257.214 60 60 2015 257.214 61 2015 257.214 2015 62 62 2015 324.337 84 84 2015 320.037 88 2015 320.0137 88 2015 420.0044 85 5213 375.048 86 60 2015 287.67 98 9015 288.437 398.338 99 90 2015 383.538 91 91 2015 2015.2029 94 94 2015 509.775 99 92 2015 279.567 99 92 2015 301.1586 99 92 2015 301.1586 99 92015 301.1586 301.158	II IY of Recruiting 5 e35,441 Advertising 279,911 79 78 2015 855,441 279,911 79 79 2015 855,441 16,6496 80 00 2015 925,7214 16,6496 81 12 2015 224,1377 20,192 83 2015 322,0137 22,7379 84 44 2015 420,0764 64,219 85 54 2015 375,048 48,4117 86 66 2015 420,0764 64,219 87 87 2015 228,702 20,194 88 2015 288,923 35,335 55,325 91 91 2015 326,927 36,233 57,8151 92 92 2015 549,7736 120,0042 22,702 94 94 2015 529,529 22,83,233 97,813 37,813 94 94 2015 529,529,52 22,83,293	# # F of Recruiting Advertising EB 77 72 2015 655.4414 27911 369.452 79 79 2015 255.2124 16.6496 21.9775 60 60 2015 257.214 16.6496 21.9775 61 80 2015 257.217 20.6298 30.914 62 62 2015 324.3377 20.1992 26.633 83 2015 324.3377 20.1992 26.633 84 84 2015 420.0746 64.2196 64.7696 65 85 2015 237.508 44.7697 10.22.65 67 87 2015 287.647 20.1041 26.5347 88 2015 88.94207 22.8322 37.4787 99 92015 284.417 39.0484 39.6477 90 2015 304.58338 57.8329 37.0478 99 92015 284.53738	# FV of Recruiting Adventing EB Incentive 77 2015 655.4414 27911.356,4452 0 79 79 2015 257.214 16.6496 21.9775 0 60 60 2015 257.214 16.6496 21.9775 0 61 81 2015 271.5776 22.0893 0 0 62 62 2015 324.3377 20.1992 26.663 0 68 82 2015 324.3377 20.1992 26.663 0 64 84 2015 420.0746 64.2196 44.7690 0 65 52 2015 271.677 20.0141 26.5374 0 66 62 2015 287.647 20.1042 26.5374 0 68 82 2015 288.4237 24.7787 0 0 99 9215 284.4178 30.0346 39.6477 0	# # FV of Recruiting 055,4414 B Incentive 129,11356,4425 Recruiter 025,773 79 2015 555,4414 25,9713 56,4542 21,9775 0 25,47 79 79 2015 257,214 16,6496 21,9775 0 25,47 60 60 60.55,4414 22,9775 0 25,21 0 25,21 61 81 2015 27,17,776 20,209 33,681 0 22,97 63 83 2015 32,0137 22,1992 26,653 0 22,97 64 84 2015 32,0137 25,7319 33,9462 0 22,19 65 85 2015 37,5048 44,112 63,904 0 21,19 66 66 2015 24,00746 64,2196 44,7696 0 22,19 76 7015 28,0147 74,8930,344 39,9457 0 225,19 88 2015 <t></t>	■ P of Recruiting Advertising B Incentive Recruiter Cost 77 72 2015 565.4414 27911 366.4454 221.9775 0 2247 208.0797 79 79 2015 255.214 16.6496 21.9775 0 2252 221.3169 60 60 2015 257.214 16.6496 21.9775 0 2252 2206.6423 61 81 2015 271.5776 22.5826 3.3991 0 2210 200.6423 62 62 2015 324.3377 20.1992 26.663 0 3272 270.055 83 2015 324.0377 27.379 3.8962 0 3212 223.647 64 84 2015 420.0746 64.2196 64.7964 0 3212 223.566 65 5015 271.677 201.5277 0 2272 223.566 68 2015 284.577	P PI of Recruiting Description B Incentive Recruiters Cost MCO 77 72 2015 865.4414 279311 369.4452 0 2247 236.507 395311 77 70 2015 257.214 16.6499 21.9775 0 2572 211.1409 30988 81 2015 271.5776 25.0396 33.0391 0 22512 206.6423 39688 82 2015 324.3377 20.3962 2.6633 0 3237 270.0355 3125 84 84 2015 324.0377 27.5719 33.9062 0 3242 26.4576 35516 84 84 2015 420.0794 64.2196 0 3212 23.5477 33.9202 26.633 0 3212 223.228 3663 3453 85 2015 420.0794 64.2196 44.107 63.9044 0 2212 23.5485 314.017 25.22	P P of Recruiting Advertising EB Incentive Recruiters Cost NCO UP 7 7 2015 865.4414 79911 594.420 0 2547 26.657 9911 594.420 3059 9911 594.420 3059 9911 594.420 3059 7.44 79 79 2015 257.2124 16.6496 21.9775 0 2520 206.6423 30689 7.44 81 2015 221.327 20.952 25.0266 33.0981 0 2232 20.65.6423 3668 7.44 82 82 2015 324.0377 20.9592 26.63 0 3237 270.0555 31.127 356 855 455 455 457.791 34.964 0 3219 24.36476 350.017 366 42.05 42.0764 42.074 26.3994 0 2112 225.366 34.40 42.924 36.956 34.74 35.957 7.00 25	# # Y of Recruiting Advertising EB Incentive Recruites Cont NCO NEO 77 72 2015 655.4414 27911 369.445 0 257.208.079 39331.7 7.44 0.95 79 79 2015 257.214 116.6496 21.9775 0 2258 206.6421 39600 7.44 0.95 61 81 2015 257.214 126.6496 21.9775 0 2258 206.6421 39600 7.44 0.95 62 62 2015 324.3377 20.1992 26.663 0 3297 270.055 33125 7.44 0.95 68 82 2015 324.094.176 0 3219 26.957 33203 7.44 0.95 68 52 2015 32.0137 22.57319 3.9604 0 3219 26.957 3320 7.44 0.95 68 52 2015 242.04.176 <td># # Y of Recruiting (55,441) EB (55,441) Incentive (55,441) Eccutive (55,441) Cost (56,541) KC0 UK2 UK3 <thuk3< th=""> <thuk3< th=""> <thuk3< th=""></thuk3<></thuk3<></thuk3<></td> <td># # Y of Recruiting 055,414 EB (55,414) Inscrittive 2015 Recruiting 205,721 Cost 206,807 NCO NESD ILEM Neemployment 200,77 79 79 2015 255,7214 166,696 21,977 0 257 26,807 39531 7.4 0,95 0.7 7 79 79 2015 255,7214 166,696 21,977 0 257 21,1146 3059 7.4 0,95 0.7 7 61 81 2015 271,577 22,5206 3,0391 0 2212 26,663 0.329 270,0355 33125 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 7,4 0,95 0.7 5 34,05 0.7 16,05 0.7 49,05 0.7</td> <td># # Y of Recruiting 565.4414 EB Incentive 106.544 Cost NCO NCO PHSDG 11.81/L Unemployment Pay 79 79 2015 255.7211 504.641 21.9775 0 2574 208.609 39331.7 7.4 0.95 0.7 7 0.4375 60 60 2015 255.721.376 20.25026 3.0991 0 2252 206.642 39600 7.44 0.95 0.7 7.4 0.95 0.7 7.5 1.03125 61 81 2015 221.3377 20.1922 26.663 0 3229 201.055 3321 7.4 0.95 0.7 7.5 1.03125 62 62 2015 32.0137 20.1922 26.663 0 3229 201.055 3325 7.4 0.95 0.7 7.4 0.95 0.7 7.5 1.03125 68 52 2015 32.0137 2.25.7378 3.26040 <td< td=""><td># # Y of Recruiting be55.441 EB Incentive set (sec) Cost (sec) NCO NEO ILIL (sec) Unemployment (sec) Pay (sec) QMA 79 70 2015 255.212 16.6496 21.975 0 257 208.690 39531 7.4 0.95 0.7 7 0.4375 188.304 60 60 2015 595.1213 22.809 0 2252 206.642 39600 7.44 0.95 0.7 7 0.4375 188.304 61 81 2015 23.21.337 20.1992 26.663 0 3207 7.44 0.95 0.7 7.5 1.03125 188.304 62 62 2015 32.0137 2.57319 3.39600 0 3212 24.577 323.0137 2.57319 3.9660 3219 201.901 3653 1.03125 0.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125<!--</td--><td># P of Recruiting Advertising EB Incentive Recruiting Cost NCO NEO 112M Unemployment Pay QMA 79 70 2015 255/214 16.646 21.9775 0 2547 20.809 3953.1 74 0.95 0.7 7 0.43175 188.3304 60 60 2015 257.214 16.646 21.9775 0 2528 20.6423 39600 7.44 0.95 0.7 7.5 5.9 0.87125 188.3304 61 81 2015 23.21377 20.9292 26.663 0 3227 20.0355 3321 7 0.4917 1.84325 188.3304 62 62 2015 32.0137 20.1922 26.663 0 3227 20.035 3325 68 82 2015 420.046 0 3219 23.467 33203 34554 67 67 7 23.108233 10.225</td><td># # P of Recruiting 055,4414 Encentive 055,4414 Recruiting 055,4414 Recruiting 055,4414 Point 055,4414 Recruiting 055,4414 Point 055,4414 Point 055,44144 Point 055,4414</td></td></td<></td>	# # Y of Recruiting (55,441) EB (55,441) Incentive (55,441) Eccutive (55,441) Cost (56,541) KC0 UK2 UK3 UK3 <thuk3< th=""> <thuk3< th=""> <thuk3< th=""></thuk3<></thuk3<></thuk3<>	# # Y of Recruiting 055,414 EB (55,414) Inscrittive 2015 Recruiting 205,721 Cost 206,807 NCO NESD ILEM Neemployment 200,77 79 79 2015 255,7214 166,696 21,977 0 257 26,807 39531 7.4 0,95 0.7 7 79 79 2015 255,7214 166,696 21,977 0 257 21,1146 3059 7.4 0,95 0.7 7 61 81 2015 271,577 22,5206 3,0391 0 2212 26,663 0.329 270,0355 33125 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 5 34,05 0.7 7,4 0,95 0.7 5 34,05 0.7 16,05 0.7 49,05 0.7	# # Y of Recruiting 565.4414 EB Incentive 106.544 Cost NCO NCO PHSDG 11.81/L Unemployment Pay 79 79 2015 255.7211 504.641 21.9775 0 2574 208.609 39331.7 7.4 0.95 0.7 7 0.4375 60 60 2015 255.721.376 20.25026 3.0991 0 2252 206.642 39600 7.44 0.95 0.7 7.4 0.95 0.7 7.5 1.03125 61 81 2015 221.3377 20.1922 26.663 0 3229 201.055 3321 7.4 0.95 0.7 7.5 1.03125 62 62 2015 32.0137 20.1922 26.663 0 3229 201.055 3325 7.4 0.95 0.7 7.4 0.95 0.7 7.5 1.03125 68 52 2015 32.0137 2.25.7378 3.26040 <td< td=""><td># # Y of Recruiting be55.441 EB Incentive set (sec) Cost (sec) NCO NEO ILIL (sec) Unemployment (sec) Pay (sec) QMA 79 70 2015 255.212 16.6496 21.975 0 257 208.690 39531 7.4 0.95 0.7 7 0.4375 188.304 60 60 2015 595.1213 22.809 0 2252 206.642 39600 7.44 0.95 0.7 7 0.4375 188.304 61 81 2015 23.21.337 20.1992 26.663 0 3207 7.44 0.95 0.7 7.5 1.03125 188.304 62 62 2015 32.0137 2.57319 3.39600 0 3212 24.577 323.0137 2.57319 3.9660 3219 201.901 3653 1.03125 0.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125<!--</td--><td># P of Recruiting Advertising EB Incentive Recruiting Cost NCO NEO 112M Unemployment Pay QMA 79 70 2015 255/214 16.646 21.9775 0 2547 20.809 3953.1 74 0.95 0.7 7 0.43175 188.3304 60 60 2015 257.214 16.646 21.9775 0 2528 20.6423 39600 7.44 0.95 0.7 7.5 5.9 0.87125 188.3304 61 81 2015 23.21377 20.9292 26.663 0 3227 20.0355 3321 7 0.4917 1.84325 188.3304 62 62 2015 32.0137 20.1922 26.663 0 3227 20.035 3325 68 82 2015 420.046 0 3219 23.467 33203 34554 67 67 7 23.108233 10.225</td><td># # P of Recruiting 055,4414 Encentive 055,4414 Recruiting 055,4414 Recruiting 055,4414 Point 055,4414 Recruiting 055,4414 Point 055,4414 Point 055,44144 Point 055,4414</td></td></td<>	# # Y of Recruiting be55.441 EB Incentive set (sec) Cost (sec) NCO NEO ILIL (sec) Unemployment (sec) Pay (sec) QMA 79 70 2015 255.212 16.6496 21.975 0 257 208.690 39531 7.4 0.95 0.7 7 0.4375 188.304 60 60 2015 595.1213 22.809 0 2252 206.642 39600 7.44 0.95 0.7 7 0.4375 188.304 61 81 2015 23.21.337 20.1992 26.663 0 3207 7.44 0.95 0.7 7.5 1.03125 188.304 62 62 2015 32.0137 2.57319 3.39600 0 3212 24.577 323.0137 2.57319 3.9660 3219 201.901 3653 1.03125 0.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 1.03125 </td <td># P of Recruiting Advertising EB Incentive Recruiting Cost NCO NEO 112M Unemployment Pay QMA 79 70 2015 255/214 16.646 21.9775 0 2547 20.809 3953.1 74 0.95 0.7 7 0.43175 188.3304 60 60 2015 257.214 16.646 21.9775 0 2528 20.6423 39600 7.44 0.95 0.7 7.5 5.9 0.87125 188.3304 61 81 2015 23.21377 20.9292 26.663 0 3227 20.0355 3321 7 0.4917 1.84325 188.3304 62 62 2015 32.0137 20.1922 26.663 0 3227 20.035 3325 68 82 2015 420.046 0 3219 23.467 33203 34554 67 67 7 23.108233 10.225</td> <td># # P of Recruiting 055,4414 Encentive 055,4414 Recruiting 055,4414 Recruiting 055,4414 Point 055,4414 Recruiting 055,4414 Point 055,4414 Point 055,44144 Point 055,4414</td>	# P of Recruiting Advertising EB Incentive Recruiting Cost NCO NEO 112M Unemployment Pay QMA 79 70 2015 255/214 16.646 21.9775 0 2547 20.809 3953.1 74 0.95 0.7 7 0.43175 188.3304 60 60 2015 257.214 16.646 21.9775 0 2528 20.6423 39600 7.44 0.95 0.7 7.5 5.9 0.87125 188.3304 61 81 2015 23.21377 20.9292 26.663 0 3227 20.0355 3321 7 0.4917 1.84325 188.3304 62 62 2015 32.0137 20.1922 26.663 0 3227 20.035 3325 68 82 2015 420.046 0 3219 23.467 33203 34554 67 67 7 23.108233 10.225	# # P of Recruiting 055,4414 Encentive 055,4414 Recruiting 055,4414 Recruiting 055,4414 Point 055,4414 Recruiting 055,4414 Point 055,4414 Point 055,44144 Point 055,4414

Step 2: To explore a group of outliers, lasso the data points of interest by creating a box around the data points with your mouse. Lassoing the data points will automatically select these data points within the greater data set.

JMP_129DesPts - JMP Pro								🕅 🕅 JMP_129DesPts - Fit Y by X of Total Cost of Recruiting by FY - JMP Pro
File Edit Tables Rows C	ols DOE Analy	ze Grap	h Tools	View Window H				
		⊦Ľx ≽	2					✓
JMP_129DesPts	4			Total Cost of			Education	1000-
 Source 		Run#	FY	Recruiting	Advertising	EB	Incentive Total	Jecn 900-
	75	75	2015	326.4324	21.667	28.6004	0	
	76	76	2015	402.9634	63.7627	84.1667	0	gr 800-
Columns (15/1)	77	77	2015	358.7623	36.6967	48,4396	0	5 800
Run #	78	78	2015	865.4414	279.911	369.4825	0	
	79	79	2015	257.214	16.6496	21.9775	0	600-
Total Cost of Recruiting	80	80	2015	959.1079	321.1317	423.8939	0	5 000
Advertising EB Education Incentive Total Recruiters Recruiter Cost NCO	81	81	2015	271.5776	25.0296	33.0391	0	500- 10-
	82	82	2015	324.3377	20.1992	26.663	0	₩ 400
	83	83	2015	332.0137	25.7319	33.9662	0	
	84	84	2015	420.0764	64.2196	84.7698	0	300-
	85	85	2015	375.048	48.4117	63.9034	0	200 2015 2016 2017 2018 2019 2020 2021
LRP	86	86	2015	406.6708	77.4697	102.26	0	
HSDG	87	87	2015	287.67	20.1041	26.5374	0	FY
TSC I-IIIA	88	88	2015	889.4207	283.8923	374.7378	0	28 rows selected
Unemployment	89	89	2015	284.4178	30.0346	39.6457	0	
Relative Pay QMA	90	90	2015	385.3536	55.325	73.029	0	3047 249.5596 35313
Quine	91	91	2015	309.2005	22.7828	30.0733	0	3039 248.9044 36172
	92	92	2015	405.8733	57.8151	76.3159	0	3227 264.3023 33984
 Rows 	93	93	2015	352.9529	38.3231	50.5865	0	3133 256.6033 37188
All rows 903	94	94	2015	509.7736	120.0042	158.4055	0	2734 223.9239 40000
elected 28		95	2015	279.5667	28.7556	37.9574	0	2508 205.4137 32578
Excluded 0	96	96	2015	847.7716	263.7513	348.1517	0	2789 228.4286 39609
Hidden 0	97	97	2015	270.0264	22.7017	29.9663	0	2563 209.9184 33359
abelled 0	00		2015	201 1594		10 0 771	0	2100 160 4670 20020 *
		4			1			

Step 3: The selected data points can be further analyzed on their own. Rightclick on "Selected."

> Columns (15/1) 🚄 Run # di. FY Total Cost of Recruiting Advertising
> EB Education Incentive Total Recruiters 🚄 Recruiter Cost A NCO 🚄 LRP HSDG 🔺 TSC I-IIIA ⊿ Unemployment 🚄 Relative Pay 📕 QMA Rows 28 Selected Excluded 0 Hidden 0 Labelled 0

Then choose "Data View" from the drop down menu.

ortod		28
	Select Rows Clear Select	
	Data View	

🔛 🍋 💕 🛃 🔉 🗈 🙈							Education	T	-
Linked Subset This subset is linke		Run #	FY	Total Cost of Recruiting	Advertising	EB	Incentive	T	1
	1	78	2015	865.4414	279.911	369.4825	0)	4
	2	80	2015	959.1079	321.1317	423.8939	0)	
Columns (15/0)	3	88	2015	889.4207	283.8923	374.7378	0)	
A Run #	4	96	2015	847.7716	263.7513	348.1517	0)	
FY FY	5	207	2016	874.0407	281.0028	370.9237	0)	
Total Cost of Recruiting	6	209	2016	968.0586	322.3843	425.5473	0)	
Advertising	7	217	2016	898.2175	284.9996	376.1995	0)	
EB Education Incentive	8	225	2016	856.4419	264.7801	349.5097	0)	
Total Recruiters	9	336	2017	879.807	282.0989	372.3705	0)	1
A Recruiter Cost	10	338	2017	974.1696	323.6418	427.2072	0	1	
NCO	11	346	2017	904.2436	286.1113	377.6669	0		
🚄 LRP	12	354	2017	862.362	265.8129	350.873	0		
HSDG	13	465	2018	885.6706	283,1992	373.8229	0		
TSC I-IIIA	14	467	2018	980.3789		428.8735	0		
Unemployment Relative Pay	15	475	2018	910.3705	287.2273	379.14	0		
QMA	15	483	2018	868.3833		352.2416	0		1
Rows	10	594	2010	891.5424		375.2811	0		
All rows 28	18	596	2019	986.5974		430.5464	0		
All rows 28 Selected 28		604	2019	916.509		380.6189	0		
Excluded 0	20	612	2019	874.4168		353.6155	0		
Hidden 0									
Labelled 0	21	723	2020	897.9872	285.4128	376.7449	0		-
							-		

Ξ

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This will create a separate data table with just the outliers.

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C. SELECT ONE FY TO ANALYZE

To focus analysis on one specific FY, the other six FYs must be hidden and excluded. In this example, FY 2017 is the FY of interest. FYs 2015, 2016, 2018, 2019, 2020, and 2021 will be hidden and excluded.

Step 1: To exclude FY 2015 and 2016, select on the first row of FY 2015 data in the furthest column to the left. Hold the "shift" keyboard button.

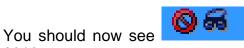
File Edit Tables Rows Col		1000		View Window H	elp
JMP_129DesPts		Ľx 🏓		Total Cost of	Advertising
Source		nun =	2015	Recruiting 302.7718	25.236
	2	2	2015	364.2534	50.360
	2	2	2015	407.1973	84.051
	4	4	2015	272.668	15.579
Columns (15/1)	4	5	2015	314,7028	24.589
Run #	6	6	2015	455.8674	80.49
FY	7	7	2015	296.7907	9,702
Total Cost of Recruiting Advertising	8	8	2015	461.4439	75.978
EB	9	9	2015	386,4563	
A Education Incentive		-			66.002
Total Recruiters	10	10	2015	410.5732	77.77
A Recruiter Cost	11	11	2015	314.3641	27.197
A NCO	12	12	2015	343.2203	47.649
LRP HSDG	13	13	2015	309.9515	8.49
TSC I-IIIA	14	14	2015	488.9989	86.76
/ Unemployment	15	15	2015	309.0097	7.237
A Relative Pay	16	16	2015	423.4232	56.306
A QMA	17	17	2015	424,451	84.321
-	18	18	2015	377.506	61.862
	19	19	2015	299.8877	27.876
	20	20	2015	324.3671	34.827
	21	21	2015	331.2071	22.348
	22	22	2015	427.0495	69.731
Rows	23	23	2015	290.6615	6.530
All rows 903 Selected 1	24	24	2015	407.0701	49.787
Excluded 0	25	25	2015	316.279	28.8
Hidden 0	26	26	2015	422.3103	74.290
abelled 0	27	27	2015	301.4469	28.831

Step 2: Scroll down to the last row of FY 2016 data (which appears in row "258"). Click on the "258" cell in the furthest column to the left.

File Edit Tables Rows Co	ols DOE Analy	ze Grapi	h Tools	View Window H	elp
🗃 🔁 🧉 🔛 🔉 🕰 🔼		Ľ <u>x</u> ≽	2		
JMP_129DesPts	۹ 💌			Total Cost of	
 Source 		Run #	FY	Recruiting	Advertising
	243	243	2016	307.3522	9.687
	244	244	2016	445.0398	66,2517
	245	245	2016	303.2966	12.11
Columns (15/1)	246	246	2016	417.8577	55.3918
Run =	247	247	2016	341.4981	38.6458
FY Total Cost of Recruiting Advertising		248	2016	447,4629	95.7411
	249	249	2016	348.5629	39.4425
		250	2016	597.7795	157.463
EB EB	251	251	2016	299.0017	11.1203
Education Incentive Total Recruiters		252	2016	393.1824	43.0785
Recruiter Cost		253	2016	345.3272	33.872
A NCO		254	2016	530.3328	114.436
LRP	255	255	2016	337.6762	47.8482
A HSDG	256	256	2016	289.7138	16.6105
TSC I-IIIA	257	257	2016	332.0182	43.4822
Unemployment Relative Pay	258	258	2016	335.8113	38.4074
OMA	259	259	2017	313.2553	25.43
- Quint	260	260	2017	375.2758	50.7542
	261	261	2017	417.9106	84.7082
	262	262	2017	282.7752	15.7012
	263	263	2017	325.5253	24.7818
	264	264	2017	468.0033	81.1232

Step 3: Right-click on the selected rows, and choose "Hide and Exclude" from the drop down menu.

	DOE Analy	and the second second	h Tools	View Windo	w H	elp
🖼 🔁 💕 🖬 🔺 🕰 🔡 👹		- Ľx >=	2			
♥JMP_129DesPts D 4				Total Cost o		
Source		Run#	FY	Recruiting		Advertising
		248 248 2016				95.7411
	249	249	2016	348	3.5629	39.442
		250	2016	597	.7795	157.463
Columns (15/1)		251	2016	299	.0017	11.120
Run #		252	2016	393	.1824	43.078
L FY		253	2016	345	.3272	33.872
A Total Cost of Recruiting		254	2016	530	114.436	
Advertising		255	2016	337	.6762	47.848
EB Education Incentive		256	2016	289	.7138	16.610
Total Recruiters		257	2016	337	.0182	43.482
A Recruiter Cost	Hide and Exclude					38.407
A NCO	Ev		.2553	25.43		
LRP	Exclude/Unexclude Hide/Unhide Label/Unlabel					50.754
A HSDG						84.708
TSC I-IIIA Unemployment						15.701
A Relative Pay	C		.5253	24.781		
QMA		arkers		50	8.0033	81.123
					.7777	9.778
	Co	olor Rows I	by Row Sta	ate	.9173	76.572
	Se	lect Match	ning Cells		.3943	66.518
	In	vert Select	ion	21	.6413	78.382
				12	5.067	27.409
Rows	CI	ear Row St	ates		.8085	48.021
All rows 903	Ac	d Rows		2	.3336	8.557
Selected 258				0	1.734	87.439
Excluded 0 Hidden 0	De	lete Rows			.4205	7.294



2016.

File Edit Tables Rows	Cols DOE Analyz	te Grapi		View Window H	elp
JMP_129DesPts Source		Run #	FY	Total Cost of Recruiting	Advertising
	S 00 248	248	2016	447.4629	95.741
	0 60 249	249	2016	348.5629	39.442
	S 🐼 250	250	2016	597.7795	157.463
Columns (15/1)	⊗ 6 251	251	2016	299.0017	11.1203
A Run =	0 6 252	252	2016	393.1824	43.0785
FY	S 🕫 253	253	2016	345.3272	33.872
Total Cost of Recruiting	S 60 254	254	2016	530.3328	114,436
Advertising	◎ 6 255	255	2016	337.6762	47.848
EB Education Incentive	◎ ∞ 256	256	2016	289.7138	16.6105
Total Recruiters	S 60 257	257	2016	332.0182	43.482
Recruiter Cost	◎ 6 258	258	2016	335.8113	38.407
A NCO	259	259	2017	313.2553	25.43
LRP LRP	260	260	2017	375.2758	50.754
A HSDG	261	261	2017	417.9106	84.708
TSC I-IIIA Unemployment	262	262	2017	282.7752	15.701
A Relative Pay	263	263	2017	325.5253	24.7818
QMA	264	264	2017	468.0033	81,123

Step 4: Follow steps 1–3 to hide and exclude data from FY 2018, 2019, 2020 and 2021. Row 388 is the first row of data for FY 2018.

File Edit Tables Rows	Cols DOE Analy		h Tools	View Window H	elp
 JMP_129DesPts Source 		Run #	FY	Total Cost of Recruiting	Advertising
Joodree	377	377	2017	451.601	96.114
	378	378	2017	352,6672	39,596
	379	379	2017	602.583	158.077
Columns (15/1)	380	380	2017	303.092	11.163
Run =	381	381	2017	397.8625	43.246
FY	382	382	2017	349.5265	34.004
Total Cost of Recruiting	383	383	2017	535.2327	114.883
Advertising	384	384	2017	341.4009	48.034
EB	385	385	2017	293.5235	16.675
Education Incentive Total Recruiters	386	386	2017	335.7705	43.651
Recruiter Cost	387	387	2017	339.7511	38.557
A NCO	388	388	2018	317.23	25.533
LRP	389	389	2018	379.5288	50.952
HSDG	390	390	2018	421.9288	85.038
TSC I-IIIA Unemployment	391	391	2018	286.5432	15.762
A Relative Pay	392	392	2018	329.7009	24.878
QMA	393	393	2018	472.8652	81.439
	394	394	2018	312.0732	9.816
	395	395	2018	478.985	76.870
	396	396	2018	401.5732	66.778
	397	397	2018	425.8783	78.688
	398	398	2018	329.168	27.516
Rows	399	399	2018	357.8098	48.208
All rows 90 Selected	400	400	2018	325.8641	8.590
	401	401	2018	506.9392	87.780
	58 402	402	2018	324.9698	7.322
Labelled	0 403	403	2018	440.7446	56.968

D. DISTRIBUTION

The distribution of the total cost of recruiting for FY 2017 is explored. This technique can be applied to any of the output variables to better understand its distribution and possible spread values.

I Distributions					
Total Cost of Recruiting					
	Quant	iles		🛛 💌 Summary S	tatistics
· · · · · · · · · · · · · · · · · · ·	100.0%	maximum	974.1696	Mean	398.24689
	99.5%		974.1696	Std Dev	124.63855
	97.5%		875.44575	Std Err Mean	10.973812
	90.0%		533.85	Upper 95% Mean	419.96045
	75.0%	quartile	433.12145	Lower 95% Mean	376.53333
	50.0%	median	361.2135	N	129
	25.0%	quartile	320.18825		
	10.0%		293.5959		
	2.5%		276.82095		
300 400 500 600 700 800 900 1000	0.5%		261.6095		
300 400 300 000 700 800 900 1000	0.0%	minimum	261.6095		

Step 1: Select "Analyze" from the ribbon, and select "Distribution" from the drop down menu.

JMP_129DesPts - JMP Pro								
File Edit Tables Rows Co	ols DOE	Anal	yze Graph Tools View	Win	dow He	lp		
IMP_129DesPts Source	 <!--</td--><td></td><td>Distribution Fit Y by X Matched Pairs Tabulate</td><td colspan="5">Distribution of a batch of values. Frequencies if categorical. Means an quantiles if continuous. Histograms, Box Plots, Quantile Plots. Tests on means, Fitting distributions. Capability.</td>		Distribution Fit Y by X Matched Pairs Tabulate	Distribution of a batch of values. Frequencies if categorical. Means an quantiles if continuous. Histograms, Box Plots, Quantile Plots. Tests on means, Fitting distributions. Capability.				
Columns (15/1)	06		Fit Model	Model 6			22.3984 149.9238	
Run # FY Total Cost of Recruiting	ତ ଜ ତ		Modeling Multivariate Methods	• •	38.6302 02.3941 52.9205	13.87 81.1356 31.5034	18.3085 107.099 41.5845	
Advertising EB Education Incentive		06 06	Quality and Process Reliability and Survival		•	38.0567 88.5754 24.4584	72.72 53.2076 74.0829	95.9904 70.234 97.7894
Total Recruiters Recruiter Cost NCO NCO			Consumer Research	•	30.8024 71.6017	9.8779	13.0388 89.1712	

Step 2: Select "Total Cost of Recruiting" from the list of columns, and click on the "Y, Columns" button.

distribution of values in each column			
lect Columns	Cast Selected	Columns into Roles	Action
15 Columns	Y, Columns	required	OK
ARun #		optional	Cancel
Total Cost of Recruiting			
Advertising	Weight	optional numeric	Remove
Education Incentive	Freq	optional numeric	Recall
Total Recruiters	By	optional	Help
ANCO			
LRP	1		
A HSDG			
TSC I-IIIA			
Unemployment			
ARelative Pay			
4QMA			

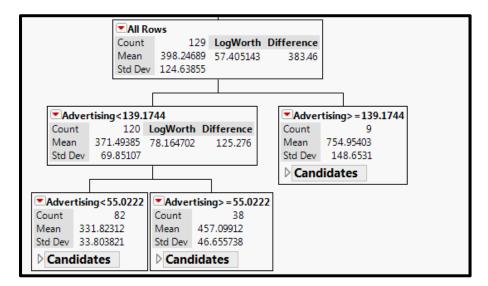
The distribution for Total Cost of Recruiting will appear.

Step 3: To rotate the distribution to appear horizontal, click on the red triangle in the upper left hand corner of the graph, and select "Stack" from the drop down menu.

istribu	itions		-	arap		View Window
	m Scaling			1	2	
	in scenny					Total Cost of
Stack						histogram and stack
Arrang	e in Rows				vertically.	distribution output
Save fo	Adobe Flash	platform (.SWF)		5	EVEL	000,000
				0	2021	361.234
Script				• 11	2021	551.042
	1			882	2021	338.630
700	1	•		883	2021	502.394
	1			884	2021	352.920
600	1	4		885	2021	438.056
	iiii .			886	2021	388.575
500				887	2021	424.458
		山山		888	2021	330.802
400				889	2021	471.601
300			Ξ	890	2021	326.058
300	ii ii			891	2021	443.760
	-			892	2021	363.545
Quant	tiles			893	2021	469.929
	maximum	974.1696		894	2021	371.076
99.5%		974.1696		895	2021	623.647
97.5%		875.44575		896	2021	321.554
90.0%	quartile	533.85 433.12145		897	2021	418.844
50.0%	median	361.2135				
25.0%	quartile	320.18825		898	2021	368.385
10.0%	1000	293.5959		899	2021	556.907
2.5%		276.82095		900	2021	358.06
0.5%		261.6095		0.01	20.21	21.0 701
0.0%	minimum	261.6095				

E. PARTITION TREES

The partition tree on total cost of recruiting will be explored. The partition tree is a useful method that can help provide insights into variable interactions.



Step 1: To create a partition tree, select "Analyze" from the ribbon. Then choose "Modeling," and "Partition" from the drop down menus.

A DE CERTE CERTE CERTE A		Anal	yze Grap	h Too	ls View \	Vind	low H	lelp					
i 🚰 🤮 🎽 🖌 🖏 🖏			Distributio	n		- 1							
 JMP_129DesPts 		Y Fit Y by X				of			Education				
💌 Source		🔀 Matched Pairs				9	9	Advertising	EB	Incentive	TotalRecruiters	Re	
	06	-				5	52.0454	90.5324	119.5028	0	2570		
	06	888	Tabulate			4	19.4008	43.8552	57.8889	0	2633		
	6					61.2343 16.9685 22.3984				0	3461		
Columns (15/1)	06	-	Fit Model			5	1.0429	113.5786	149.9238	0	3078		
A Run #	06		Modeling •				Partition			Recursively partition the data to			
Total Cost of Recruiting	06	-	Multivaria	te Methy	ode		izi Ne			predict a response. Classification and			
Advertising	06	R Maintainate Methods			0.1			regression tree	is.	_			
🖌 EB	06		Quality an	d Proces	is		T Mo	odel Compariso	on	0	2875		
Education Incentive	06		Reliability	and Sun	rival		· No	onlinear		0	2828		
Total Recruiters Recruiter Cost	06									0	2688		
NCO	06		Consumer	Researc	h	•	🍌 Ga	ussian Process		0	3305		
LRP	ଷ୍ଟ	889	889	2021		-	what Tir	me Series		0	3383		
HSDG	06	890	890	2021						0	3188		
TSC I-IIIA	06	891	891	2021		1	Sci			Screening		0	3359
Unemployment	08	892	892	2021			27 De		22	0	2906		
A Relative Pay	06	893	893	2021		1	Z Re	sponse Screeni	ng	0	2586		

Step 2: Select "Total Cost of Recruiting" from the list of columns, and click on the "Y, Response" button.

Recursive partitioning			
Select Columns	Cast Selected	Columns into Roles ———	Action —
■15 Columns	Y, Response	required	ОК
ARun #		optional	Cancel
Total Cost of Recruiting			
Advertising	X, Factor	required	Remove
EB Education Incentive		optional	Recall
Total Recruiters			
Recruiter Cost			Help
ANCO	Weight	optional numeric	
ALRP HSDG	Freq	optional numeric	
ITSC I-ⅢA	Validation	optional numeric	
Unemployment	By	optional	
ARelative Pay			
⊿ QMA			
✓ Informative Missing			
Ordinal Restricts Order			
Validation Portion 0			
Method Decision Tree			
			🚹 🔳 🔻 🔡

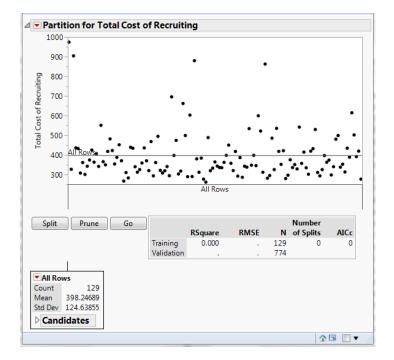
Step 3: Select each decision variable (Advertising, EB, Education Incentive, Total Recruiters) from the list of columns, then click on the "X, Factor" button.

elect Columns	Cast Selected	Columns into Roles ——	Action -
15 Columns	Y. Response	Total Cost Recruiting	OK
Arun # FY Total Cost of Recruiting		optional	Cance
Advertising EB Education Incentive Total Recruiters	X, Factor	required optional	Remov Recall Help
Recruiter Cost	Weight	optional numeric	
	Freq	optional numeric	
TSC I-IIIA	Validation	optional numeric	
Unemployment Relative Pay QMA	Ву	optional	
Informative Missing Ordinal Restricts Order alidation Portion	0]		
lathad	•		

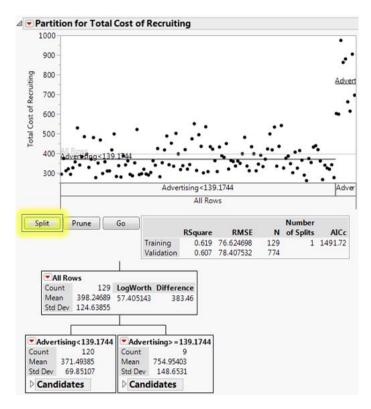
Step 4: Click on the "OK" button.

Recursive partitioning				
Select Columns	Cast Selected	Columns into Roles ———	Act	ion
15 Columns	Y, Response	Total Cost Recruiting		ОК
ARun #	<u> </u>	optional		ancel
ILFY				ancer
Total Cost of Recruiting				
Advertising FB	X, Factor	Advertising	Re	emove
Education Incentive		∠ EB		Recall
Total Recruiters		Education Incentive		
Recruiter Cost		Total Recruiters		Help
⊿ NCO	Weight	optional numeric		
⊿LRP IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	Freq	optional numeric		
A HSDG				
TSC I-IIIA	Validation	optional numeric		
/Unemployment	By	optional		
ARelative Pay AOMA				
✓ Informative Missing				
✓ Ordinal Restricts Order				
Validation Portion 0				
Method Decision Tree				
Decision Tree				

The partition tree window will pop-up with just the parent node.



Step 5: To make the first split on "Total Cost of Recruiting," click on the "Split" button.

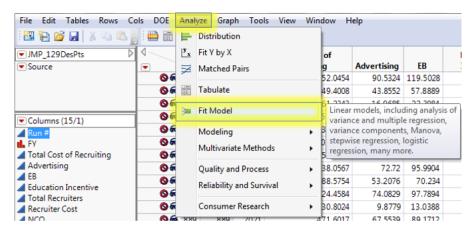


Continue to split, by clicking the "Split" button. If you want to undo a split, click on the "Prune" button. A "Training" R^2 value of 0.80 is an adequate threshold to achieve. In this case, disregard the "Validation" R^2 value.

F. STEPWISE REGRESSION MODEL

To develop a model for the total cost of recruiting, stepwise regression is used to determine the beta estimates to fit a model.

Step 1: Select "Analyze" from the ribbon, then "Fit Model" from the drop down menu.



Step 2: Select "Total Cost of Recruiting" from the list of columns, and click on the "Y" button.

Model Specification			
Select Columns	Pick Role Va	riables	Personality:
■15 Columns	Y	required	
ARun #		optional	
EY.			Help Run
Advertising	Weight	optional numeric	
A BB	Freq	optional numeric	Recall Keep dialog open
Education Incentive			Remove
Total Recruiters	By	optional	
Recruiter Cost	Construct b	Iodel Effects	
ANCO			
	Add		
	Cross		
/Unemployment	Nest		
Relative Pay			
4QMA	Macros	•	
	Degree	2	
	Attributes		
	Transform	•	
	📃 No Inter	cept	

Step 3: While holding the Ctrl key, select each market factor that was varied in the PROM-WED excursion.

✓ ■ Model Specification		
Select Columns	Pick Role Variables	Personality: Standard Least Squares 🔹
15 Columns	γ / Total Cost of Recruiting	
ARun #	optional	Emphasis: Effect Leverage 🔹
FY		
Total Cost of Recruiting Advertising	Weight optional numeric	
EB	Freq Optional numeric	Help
Education Incentive		Recall 📃 Keep dialog open
Total Recruiters	Validation optional	Remove
Recruiter Cost	By optional	
NCO		
	Construct Model Effects]
TSC I-IIIA	Add	
	Cross	
Relative Pay		
4QMA	Nest	
	Macros 🕶	
	Degree 2	
	Attributes 💌	
	Transform 💌	
	No Intercept	
	·	

Select the right corner of the "Macros" button (i.e., the arrow), and select "Factorial to degree" from the drop-down menu.

elect Columns	Pick Role Va	riables	Personality:	Standard Least Square
15 Columns Run # FY	Y	Total Cost of Recruiting optional	Emphasis:	Effect Leverage
Total Cost of Recruiting	Weight	optional numeric	Help	Run
AEB	Freq	optional numeric		
Education Incentive Total Recruiters	Validation	optional	Recall	Keep dialog open
Recruiter Cost	Ву	optional	Remove	
LRP HSDG TSC I-IIIA	- Construct M Add	lodel Effects		
Unemployment	Cross			
Relative Pay	Nest			
	Macros	-		
	Full F	actorial		
	Facto	rial to degree		ed columns and
	Facto	rial sorted		s up to the specified ,, degree 2 enters main
	Respo	onse Surface		two-way interactions.

This will add all main effect and two-way interactions.

elect Columns	Pick Role Variables Personality: Standard Least Square
15 Columns	Y Total Cost of Recruiting optional Emphasis: Effect Leverage
Atvertising	Weight optional numeric Help Run
⊿ев	Freq optional numeric
Education Incentive Total Recruiters	Validation optional Remove
Recruiter Cost	By optional
LRP HSDG TSC I-IIIA Unemployment Relative Pay QMA	Construct Model Effects Add NCO Unemployment Relative Pay Nest NCO"Unemployment NCO"Relative Pay Unemployment*Relative Pay Degree 2 Attributes Transform Transform

Again, while holding the Ctrl key, select each market factor that was varied in the PROM-WED excursion. Select the right corner of the "Macros" button (i.e., the arrow), and select "Polynomial to degree" from the drop-down menu. This will add all second degree polynomial interactions.

Model Specification Select Columns	Pick Role Va	riables	Personality:	Standard Least Squares	-
■15 Columns ■Run #	Y	Total Cost of Recruiting optional	Emphasis:	Effect Leverage	•
Total Cost of Recruiting	Weight	optional numeric	Help	Run	
⊿ EB	Freq	optional numeric			
Education Incentive Total Recruiters	Validation	optional	Recall	Keep dialog open	
Recruiter Cost	By	optional	Remove		
ILRP HSDG	- Construct M	lodel Effects			
TSC I-IIIA	Add	NCO Unemployment			
Unemployment Relative Pay	Cross	Relative Pay			
A QMA	Nest	NCO*Unemployment NCO*Relative Pay			
	Macro		Pay		
	Facto	actorial rial to degree rial sorted onse Surface			
	Mistu	re Response Surface	-	Cross	e Pay
		nomial to Degree	and their p	lected columns (say, X) owers (X*X, X*X*X, etc.) up	lativ pym
			to the spec	cified degree.	1

Step 4: From the "Personality" drop-down menu, select "Stepwise."

elect Columns	Pick Role Variables	Personality:	Standard Least Squares
15 Columns Aun # FY	Y all Total Cost of Recruiting optional	Emphasis:	Standard Least Squares Stepwise Generalized Regression
 Total Cost of Recruiting Advertising 	Weight optional numeric	Help	Mixed Model Manova
■EB ■Education Incentive	Freq optional numeric	Recall	Loglinear Variance Nominal Logistic
Total Recruiters	Validation optional By optional	Remove	Ordinal Logistic Proportional Hazard
	Construct Model Effects		Parametric Survival Generalized Linear Mod
▲HSDG ▲TSC I-IIIA	Add NCO Unemployment		Partial Least Squares Response Screening
Unemployment Relative Pay QMA	Cross Relative Pay Nest NCO*Unemployment NCO*Relative Pay		
	Macros V Degree 2 Unemployment*Relative NCO*NCO Unemployment*Unemploy		
	Attributes Transform Relative Pay*Relative Pay	-	

Step 5: Ensure that the "Keep dialog open" box is checked, and click the "Run" button.

elect Columns	Pick Role Va	riables	Personality:	Stepwise
15 Columns Ann #	Y	Total Cost of Recruiting		Stephise
A FY		optional	Help	Run
Total Cost of Recruiting Advertising	Weight	optional numeric	Recall	
AEB	Freq	optional numeric		Keep dialog open
Education Incentive Total Recruiters	Validation	optional	Remove	
ARecruiter Cost	Ву	optional		
	Construct M			
TSC I-IIIA	Add	NCO Unemployment		
Unemployment Relative Pay	Cross	Relative Pay		
	Nest	NCO*Unemployment NCO*Relative Pay		
	Macros		Pay	
	Degree [Attributes] Transform	Relative Day*Relative Day		
	No Inter			

Step 6: The "Stepwise Regression Control" window will appear. Press the "Go" button.

Stepwise Re	gression Co	ntrol									
Stopping Rule:	Minimum BIG	C	•	-	Enter All	Mak	e Moo	iel			
Direction:	Forward •]		-	Remove All	Run	Mod	el			
Rules:	Combine	•									
Go	Stop Ste	ep									
774 rows not us	ed due to exclu	uded rows of	or missing	g valu	es.						
SSE DE	E RMSE	RSquare	RSquare	e Adj	Ср	Р		AICc	BIC		
1988450.3 12	28 124.63855	0.0000	0.	.0000	717.81945	1	1614	.135	1619.76		
Current Esti	mates										
Lock Entered						Esti	mate	nDF	SS	"F Ratio"	"Prob>F
						Esti 398.2		nDF	SS 0	"F Ratio" 0.000	"Prob>F
Lock Entered	Parameter								0		
Lock Entered	Parameter Intercept	nt					46889	1	0	0.000	4.6e-1
Lock Entered	Parameter Intercept NCO	nt					46889 0	1	0 720111.2	0.000 72.105 7.314	4.6e-1
Lock Entered	Parameter Intercept NCO Unemploymer		loyment-	6.0031			46889 0 0	1 1 1	0 720111.2 108286.7	0.000 72.105 7.314	4.6e-1 0.0077 3.2e-1
Lock Entered	Parameter Intercept NCO Unemploymer Relative Pay	1)*(Unemp		6.0031			46889 0 0 0	1 1 1	0 720111.2 108286.7 533851.6	0.000 72.105 7.314 46.610	4.6e-1 0.0077 3.2e-1 6.8e-1
Lock Entered	Parameter Intercept NCO Unemploymer Relative Pay (NCO-35000.1	1)*(Unemp 1)*(Relative	Pay-1)		IJ		46889 0 0 0 0	1 1 1 3	0 720111.2 108286.7 533851.6 841588.2	0.000 72.105 7.314 46.610 30.576	4.6e-1- 0.0077 3.2e-1 6.8e-1 9.2e-3
	Parameter Intercept NCO Unemploymer Relative Pay (NCO-35000.1 (NCO-35000.1	1)*(Unemp 1)*(Relative nt-6.0031)	Pay-1) *(Relative		IJ		46889 0 0 0 0 0	1 1 1 3 3	0 720111.2 108286.7 533851.6 841588.2 1459125 657070.1	0.000 72.105 7.314 46.610 30.576 114.857	4.6e-1 0.0077 3.2e-1 6.8e-1 9.2e-3 6.8e-1
Lock Entered	Parameter Intercept NCO Unemploymer Relative Pay (NCO-35000. (NCO-35000.) (Unemployme	1)*(Unemp 1)*(Relative nt-6.0031) 1)*(NCO-3!	e Pay-1))*(Relative 5000.1)	e Pay-	1) 1)		46889 0 0 0 0 0 0	1 1 1 3 3 3 2	0 720111.2 108286.7 533851.6 841588.2 1459125 657070.1	0.000 72.105 7.314 46.610 30.576 114.857 20.564 45.860	"Prob>F 4.6e-1 0.0077 3.2e-1 6.8e-1 9.2e-3 6.8e-1 1.1e-1 0.0268

Step 7: Once settled, select the "Run Model" button.

Ste	pwise	Regres	sion Co	ntrol												
Stop	pping R	ule: Mir	nimum BI	0		Enter All	Make	Model								
Dire	ection:	For	ward 🔻]	•	Remove Al	Run M	1odel								
Rule				, 			-					1.00				
Nuit	C3.	Cor	mbine	•				Ļ	ake cur	rent n	nodel	and fit i	t in a se	parate fu	ll-featured fit	ing platfo
	Go	Stop	Ste	ep												
774	rows no	t used du	e to exclu	ded rows	or missing value	5.										
	SSE	DFE	RMSE	RSquare	RSquare Adj	Cp	p	AIC	c	BIC						
2869			8.902517	0.8557	0.8461	10.92502			- 7 1408							7
Cur	rent E	stimat	es													
Lock	k Enter	red Para	meter				Estima	nte ni	F	SS	"F R	atio" '	'Prob>f			incide -
1	1	Inter	cept				150.492	117	1	0	(0.000		1		
	-	NCC)				0.02552	572	4 103	4475	10	8.143	7.7e-3	9		
	-	Une	mploymer	nt			-24.598	171	3 132	374.1	1	8.451	6.6e-1	.0		
	1	Rela	tive Pay				-550.249	982	4 734	128.1	7	6.745	3.7e-3	2		
	-	(NCC	D-35000.:	1)*(Unemp	loyment-6.0031)	-0.00354	13	1 160	62.16		6.716	0.0107	4		
	-	(NCC	D-35000.:	1)*(Relativ	e Pay-1)		-0.12314	431	1 163	847.2	6	8.514	2e-1	3		
	-	(Une	employme	nt-6.0031)*(Relative Pay-1	.)	84.0662	002	1 156	60.78		6.549	0.0117	4		
	-	(NC	0-35000.:	1)*(NCO-3	5000.1)		3.09283	e-6	1 627	84.13	2	6.254	1.16e	-6		
		(Une	mployme	nt-6.0031)*(Unemployme	nt-6.0031)		0	1 688	4.615		2.925	0.0898	2		
	1	(Rela	ative Pay-:	1)*(Relativ	e Pay-1)		1907.37	931	1 630	96.42	2	6.384	1.1e	6		
Ste	p Hist	ory														
Ste	p Pa	ameter				Action	"Sig Pr	ob"	Seq SS	RSq	uare	Cp	Р	AICc	BIC	
	1 (N	0-3500	0.1)*(Rela	tive Pay-1)		Entered	0.0	0000 1	459125	0.	7338	103.89	4	1449.8	1463.61 🔘	
	2 Un	employm	ent			Entered	0.0	0000 1	05529.6	0.	7869	61.055	5	1423.31	1439.78 🔘	
	3 (N	0-3500	0.1)*(NCC	-35000.1)		Entered	0.0	0001 4	8541.67	0.	8113	42.432	6	1409.86	1428.95 🔘	
	4 (Re	lative Pay	y-1)*(Rela	tive Pay-1)	Entered	0.0	0000 6	1580.54	0.	8423	18.268	7	1389.01	1410.69 🔘	
	5 (N	0-3500	0.1)*(Une	mploymen	t-6.0031)	Entered	0.0	377 1	1038.26	0.	8478	15.579	8	1386.7	1410.93 🔘	
(6 (Ur	nemployn	nent-6.00	31)*(Relat	ive Pay-1)	Entered	0.0)117 1	5660.78	0.	8557	10.925	9	1382.2	1408.93 🔘	10.1
	7 (Ur	nemployn	nent-6.00	31)*(Unen	ployment-6.00	31) Entered	0.0	898 6	884.615	0.	8591	10	10	1381.46	1410.66 🔘	

The "Report: Fit Model" window will appear.

it Grou	р								
Respo	nse Tot	tal Cost o	of Recruit	ing					
Effect S	umma	ry							
Source			LogWort	:h				F	Value
NCO			33.55						00000
Relative			28.27						00000
	elative Pa	у	12.69						00000
Unempl			9.03						00000
		ative Pay	5.96						00000
NCO*N			5.93						00000
	nemploy		1.96						01074
		Relative Pa	·		: :	1 1		; 0.	01174
Remov	<u>e Add E</u>	idit 🔲 FD	R						
Summa	rv of F	it							
RSquare		-	0.855679						
RSquare A	di		0.846058						
Root Mea		Error	48.90252						
Mean of R			398.2469						
Observatio	ons (or S	um Wgts)	129						
Analysi	s of Va	riance							
		Sum of	f						
Source	DF	Square	s Mean Squ	uare F	Ratio				
Model	8	1701475.	5 212	2684 88	3.9351				
Error	120	286974.	-	2391 Pro					
C. Total	128	1988450.3	3	<.	0001*				
Parame	ter Est	imates							
Term								Prob> t	
Intercept				150.492		3.20602		0.0293*	
NCO				0.02552).00148			
Unemploy				-24.598				<.0001*	
							-14.87		
Relative P					41 ().	001366	-2.59	0.0107*	
(NCO-350							0.00	< 0001*	
(NCO-350 (NCO-350	000.1)*(R	Relative Pay	-1)	-0.1231	.43 0.	014877		<.0001*	
(NCO-350 (NCO-350 (Unemplo	000.1)*(R yment-6	Relative Pay	-1) lative Pay-1)		.43 0. 62 3		2.56		

At this point, you can decide if you would like to make manual adjustments to the stepwise regression. For example, the interactions between unemployment rate and relative pay, and the new accession mission and unemployment in this example both exhibit low "t Ratio" values.

To remove these terms from the model, return to the "Stepwise Fit" window, and uncheck the terms in the "Entered" column that you would like to remove. Select "Run Model" to fit the new model.

Stepw	vise Regression Control									
Stoppi	ng Rule: Minimum BIC 🔹 🗭	Enter All	Make Mod	el						
Directi	on: Forward V	lemove All	Run Mode	1						
Rules:	Combine 🔹									
Go	Stop Step									
774 rov	vs not used due to excluded rows or missing values	5.								
SS		Ср		ICc	BIC					
303036	.9 121 50.044352 0.8476 0.8388 1 nt Estimates	15.749241	8 1386	.871	1411.096					
	Intered Parameter		Estimate	nDi	s s	S "F Ratio	" "Pro	ob>F"	1	
			151.602299	1		0.00	CC/ 02	1		
			0.02552971		101841 116311	T. T. T. T. M. T.		6e-38		
	Relative Pay		-550.43355		742311			3e-31		
i i			0	1	16062.1	6 6.71	16 0.	01074		
	(NCO-35000.1)*(Relative Pay-1)		-0.1277552	1	178910	4 71.4	37 7.	.6e-14		
			68.0443421	1	10636.8	-	100 C	04146		
			2.93986e-6	1			59 4.	.94e-6		
			0 1917.11709		9014.02 63748.8	-	-	05748 61e-6		
Steph	listory									
Step	Parameter	Action	"Sig Prot	, "	Seq SS	RSquare	Ср	р	AICc	BIC
1	(NCO-35000.1)*(Relative Pay-1)	Entered	0.00	00 1	459125	0.7338 1	03.89	4	1449.8	1463.61
2	Unemployment	Entered			05529.6	0.7869 6				1439.78
3	(NCO-35000.1)*(NCO-35000.1)	Entered			8541.67	0.8113 4				1428.95
4	(Relative Pay-1)*(Relative Pay-1)	Entered			1580.54	0.8423 1				1410.69
5	(NCO-35000.1)*(Unemployment-6.0031)	Entered			1038.26	0.8478 1		8		1410.93
6	(Unemployment-6.0031)*(Relative Pay-1)	Entered	2011	12.	5660.78	0.8557 1		9		1408.93
7	(Unemployment-6.0031)*(Unemployment-6.003		0.08	18 6	884.615	0.8591	10			1410.66
8	Best (NCO-35000.1)*(Unemployment-6.0031)	Specific			6062.16	0.8557 1		9	1382.2 1386.87	1408.93
9		Remove								

Step 8: To graph the "Actual by Predicted" plot, select the red triangle next to "Response Total Cost of Recruiting." From the drop-down menu, select "Row Diagnostics" and "Plot Actual by Predicted."

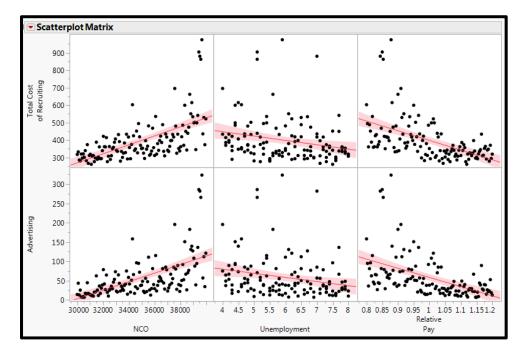
Fit Group				
Response Total Cost	t of Recru	iting		AaBbCcDi Aa
Regression Reports	•			Subtle Em En
Estimates Effect Screening	• 33	orth .553	PValue 0.00000 0.00000	
Factor Profiling Row Diagnostics		Plot Actual by Predicted	Actual response	value on Y axis, by on the X axis. In good
Save Columns Model Dialog	•	Plot Effect Leverage Plot Residual by Predicted	fits, points are n	ear the diagonal. You oints do not fit, look
Effect Summary Script		Plot Residual by Row Press		

Step 9: To fit the prediction model, select the red triangle next to "Response Total Cost of Recruiting." From the drop-down menu, select "Estimates" then "Show Prediction Expression."

tC	Froup			- In I
Re	sponse Total Cos	t of Rec	ruiting	
-	Regression Reports			
	Estimates		Show Prediction Expression	Displays or hides the predictio formula in the report.
-	Effect Screening		Sorted Estimates	0.00000
	Factor Profiling	•	Expanded Estimates	0.00000 0.00000
	Row Diagnostics	•	Sequential Tests	0.00000
	Save Columns	•	Custom Test	0.00000
	Model Dialog		Multiple Comparisons	0.01074
1	Effect Summary		Joint Factor Tests	0.01174
	Script		Inverse Prediction	
	aruh.		Decompation Decomp	

G. SCATTERPLOT MATRIX

Scatterplot matrices can be used to visualize trends when multiple variables are changing.



Step 1: Select "Graph" from the ribbon, then "Scatterplot Matrix" from the drop down menu.

File Edit Tables Rows	Cols DOE Analyze	Grap	h Tools View Window	H	lelp		
i 🔛 🥁 💕 📕 36 🐴 📖	📙 🖶 🛗 🖽 🖛 🖄		Graph Builder				
JMP_129DesPts		0.	Bubble Plot				Educati
 Source 	R	14	Company last Marking	L	Advarticina	CD	Incont
	◎ 🕷 878	Lange Scatterplot Matrix		Displays multivariate data in a grid of 2-dimensional scatterplots.			
	⊗ <i>€</i> 879	HH	Parallel Plot	D8	+3.0332	27.0005	
	S 880	1	Cell Plot	43	16.9685	22.3984	
Columns (15/1)	⊗ <i>€</i> 881	Lets		29	113.5786	149.9238	
Run #	\$€ 882	洪	Scatterplot 3D	02	13.87	18.3085	
FY	⊗ <i>€</i> 883	2	Contour Plot	41	81.1356	107.099	
Total Cost of Recruiting	⊗ € 884	A	Ternary Plot	05	31.5034	41.5845	
Advertising	200 2 4	1-1	remary riot	17	73 73	05 0004	

Step 2: To set the Y-axis variables, select "Total Cost of Recruiting" and "Advertising" from the list of columns, and click on the "Y, Columns" button.

Scatterplots of all pairs of Y variables, or all X-Y pairs if	X's specified		
Select Columns	Cast Selected	Columns into Roles	Action —
15 Columns	Y, Columns	required	ОК
ARun #		optional	Cancel
IL EV			Cancer
Total Cost of Recruiting			
Advertising	X	optional	Remove
Education Incentive			Recall
Total Recruiters			Help
ARecruiter Cost		antine d	Пер
	Group	optional	
	Ву	optional	
TSC I-IIIA			
/Unemployment			
ARelative Pay			
⊿ QMA			
Matrix Format Lower Triangular 💌			

Step 3: To set the X-axis variables, select the variables of interest (NCO, Unemployment Rate and Relative Pay in this case), and click on the "X" button.

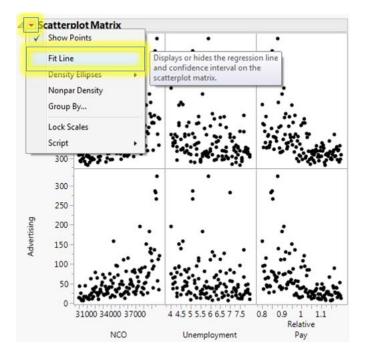
Scatterplots of all pairs of Y variables, or all X-Y pairs if	X's specified		
- Select Columns	Cast Selected	Columns into Roles	Action —
15 Columns	Y. Columns	Total Cost Recruiting	ОК
ARun #		Advertising	
L FY		optional	Cancel
Total Cost of Recruiting			
Advertising	X	optional	Remove
⊿ EB			
Education Incentive			Recall
Total Recruiters			Help
Recruiter Cost	Group	optional	
NCO			
	Ву	optional	
TSC I-IIIA			
/Unemployment			J
ARelative Pay			
4QMA			
Matrix Format Lower Triangular 👻			
			🔒 🔲 🔻 🔡

Step 4: Repeat Step 3 for Unemployment Rate and Relative Pay.

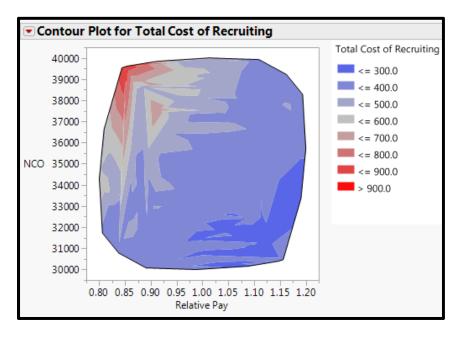
Step 5: To generate the scatterplot matrix, click the "OK" button.

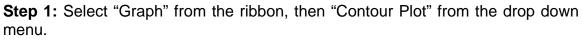
atterplots of all pairs of Y variables, or all X Select Columns	and the second	Columns into Roles	Action
15 Columns Run # FY Total Cost of Recruiting Advertising EB Education Incentive Total Recruiters Recruiter Cost NCO LRP HSDG TSC I-IIIA	Y, Columns X Group By	 Total Cost Recruiting Advertising optional NCO Unemployment Relative Pay optional optional optional 	OK Cancel Remove Recall Help
Unemployment Relative Pay ■QMA Matrix Format Lower Triangular ▼			

Step 6: To fit a trend line on the plots, click the red triangle, and select "Fit Line" from the drop down menu.



H. CONTOUR PLOTS





File Edit Tables Rows	Cols DOE Analyze	Grap	h Tools View Window	/ H	lelp		
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■ JMP_129DesPts ■ Source					Advertising	EB	Edu Ince
	⊗ <i>€</i> 878	1000	Scatterplot Matrix	54	90.5324	119.5028	
	⊗ <i>€</i> 879		Parallel Plot	08	43.8552	57.8889	
	S80	1	Cell Plot	43	16.9685	22.3984	
Columns (15/1)	S 881			29	113.5786	149.9238	
Run #	\$ 682	头	Scatterplot 3D	02	13.87	18.3085	
FY	⊗ <i>€</i> 883	2	Contour Plot	4	Displays three	variables in a	2-
Total Cost of Recruiting	⊗ € 884	A	A Ternary Plot	P -1	dimensional view where the thi		
Advertising	S 885	E:1	A Temary Plot		variable is represented by curves of equal value.		contour
EB	⊗ <i>€</i> 886	1	Surface Plot	54	curves of equa	1 Value.	

Step 2: To set "Total Cost of Recruiting" as the variable represented by the color scale, select "Total Cost of Recruiting" from the list of columns, and click the "Y" button.

Step 3: To set "Relative Pay" as the x-axis, select "Relative Pay" from the list of columns, and click the "X" button.

Please specify two X columns and one or more Y colur	mns.
Select Columns	Cast Selected Columns into Roles Action
Total Cost of Recruiting Advertising EB	Y Total Cost Recruiting optional numeric OK Cancel
Education Incentive Total Recruiters Recruiter Cost NCO LRP HSDG	By optional Recall Help
TSC I-IIIA Unemployment Relative Pay QMA	
Options Contour Values: Checify Patriava	
Display: Fill Areas	
Data: Vise Table Data Specify Grid	

Step 4: To set the new accession mission (NCO) as the y-axis, select "NCO" from the list of columns, and click the "X" button.

Please specify two X columns and one or more Y colum	ins.	
Select Columns ■15 Columns	Cast Selected Columns into Roles	Action OK
Run # FY Total Cost of Recruiting Advertising EB Education Incentive Total Recruiters Recruiter Cost NCO LRP HSDG TSC I-IIIA Unemployment Relative Pay QMA	optional numeric X Relative Pay required numeric By optional	Cancel Remove Recall Help
Options Contour Values: Specify Retrieve		
Display: Fill Areas		
Data: Use Table Data Specify Grid		^ □ ▼
		🛄 🔛 🎽 HH

Step 5: Select the "Fill Areas" box, then click the "OK" button to generate the contour plot.

Please specify two X columns and one or more Y co	lumns.	
- Select Columns	Cast Selected Columns into Roles	Action —
■15 Columns	Y A Total Cost Recruiting	ОК
Continue Advertising Advertising EB Education Incentive Total Recruiters Recruiter Cost NCO LRP HSDG TSC I-IIIA Unemployment Relative Pay QMA Options Contour Values: Specify Display: V Fill Areas	x Relative Pay NCO By optional	Cancel Remove Recall Help
Data: Use Table Data Specify Grid		
		1 🗈 🗖 🖉

V. EXAMPLE TEST CASES

Two test case examples are provided to demonstrate PROM-WED's capabilities.

A. EFFECT OF ECONOMIC UNCERTAINTIES

What is the optimal allocation of recruiting resources that is robust to a broad range of economic uncertainties?

Variable Type	Variable Name	Value Low	Value High
Decision Variable	Recruiters	2,500 recruiters	3,500 recruiters
Market Factor	Unemployment Rate	4.0%	8.0%
Market Factor	Relative Pay	0.80	1.20
Policy Factor	Recruiting Mission (NCO)	30,000 recruits	40,000 recruits

B. EFFECT OF LEGALIZATION OF MARIJUANA TEST CASE:

What is the optimal allocation of recruiting resources if the Navy desires to increase the percentage of high quality recruits from 70 percent to 85 percent? Due to uncertainties in the current fiscal environment, the unemployment rate may fluctuate between 4 to 8 percent and the ratio of relative pay may vary between 0.8 and 1.2. In addition, since marijuana has been legalized for recreational use in many states nationwide, drug-use amongst 18–24 year-olds is expected to increase. An increase in drug-use means less young adults qualify for military service. This test case models the effect of an annual decrease of 10,000 qualified military available due to pre-service drug-use.

Variable Type	Variable Name	Value Low	Value High
Decision Variable	Production Recruiters	2,500 recruiters	3,500 recruiters
Market Factor	Unemployment Rate (UE)	4.0%	8.0%
Market Factor	Percentage of High Quality Recruits (TSC I-III)	70%	85%
Market Factor	Relative Pay	0.8	1.2
Market Factor	Qualified Military Available (QMA)	*See Table 13	
Policy Factor	Recruiting Mission (NCO)	30,000 recruits	40,000 recruits

FY	QMA Value Low	QMA Value High
2015	1,873,304	1,883,304
2016	1,863,304	1,873,304
2017	1,853,304	1,863,304
2018	1,843,304	1,853,304
2019	1,833,304	1,843,304
2020	1,823,304	1,833,304
2021	1,813,304	1,823,304

Cumulative Effect of Decrease in QMA

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APPENDIX D. SCENARIO INPUT REPORTS

A. PARAMETER INPUTS FOR FIGURE 45

Where "Recruiters" is the only variable that is fixed. EB, NCF, and advertising are floated.

		2015	2016	2017	2018	2019	2020	2021
NCF	high	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	low	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
UE	high	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	low	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Recruiters	high	3913	3913	3913	3913	3913	3913	3913
	low	3913	3913	3913	3913	3913	3913	3913
LRP	high	7.44	11.22	11.28	11.38	11.43	11.46	11.67
	low	7.44	11.22	11.28	11.38	11.43	11.46	11.67
Advertising	high	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
	low	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
EB	high	40.971	40.971	40.971	40.971	40.971	40.971	40.971
	low	40.971	40.971	40.971	40.971	40.971	40.971	40.971
NCO	high	35025	36425	36800	35800	35225	34650	34650
	low	35025	36425	36800	35800	35225	34650	34650
TSC	high	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	low	0.7	0.7	0.7	0.7	0.7	0.7	0.7
HSDG	high	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	low	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Rel Pay	high	1.2	1.2	1.2	1.2	1.2	1.2	1.2
	low	1.2	1.2	1.2	1.2	1.2	1.2	1.2
QMA	high	1883304	1883304	1883304	1883304	1883304	1883304	1883304
	low	1883304	1883304	1883304	1883304	1883304	1883304	1883304

B. PARAMETER INPUTS FOR FIGURE 46

Where "Recruiters" is the only variable that is fixed. EB, NCF, and advertising are floated.

		2015	2016	2017	2018	2019	2020	2021
NCF	high	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
NCF	Low	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
UE	high	0.08	0.08	0.08	0.08	0.08	0.08	0.08
UL	Low	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Recruiters	high	3500	3500	3500	3500	3500	3500	3500
Recruiters	Low	2500	2500	2500	2500	2500	2500	2500
LRP	high	7.44	11.22	11.28	11.38	11.43	11.46	11.67
LIXF	Low	7.44	11.22	11.28	11.38	11.43	11.46	11.67
Advertising	high	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
Auvertising	Low	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
EB	high	40.971	40.971	40.971	40.971	40.971	40.971	40.971
	Low	40.971	40.971	40.971	40.971	40.971	40.971	40.971
NCO	high	35025	36425	36800	35800	35225	34650	34650
NCO	Low	35025	36425	36800	35800	35225	34650	34650
тѕс	high	0.7	0.7	0.7	0.7	0.7	0.7	0.7
130	Low	0.7	0.7	0.7	0.7	0.7	0.7	0.7
HSDG	high	0.95	0.95	0.95	0.95	0.95	0.95	0.95
11300	Low	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Rel Pay	high	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Renay	Low	1.2	1.2	1.2	1.2	1.2	1.2	1.2
QMA	high	1883304	1883304	1883304	1883304	1883304	1883304	1883304
QIVIA	Low	1883304	1883304	1883304	1883304	1883304	1883304	1883304

C. PARAMETER INPUTS FOR TEST CASE 1

Where "Recruiters" is the only variable that is fixed. EB, NCF, and advertising are floated.

		2015	2016	2017	2018	2019	2020	2021
NCF	high	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
NCF	Low	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
UE	high	0.08	0.08	0.08	0.08	0.08	0.08	0.08
UL	Low	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Recruiters	high	3500	3500	3500	3500	3500	3500	3500
Recruiters	Low	2500	2500	2500	2500	2500	2500	2500
LRP	high	7.44	11.22	11.28	11.38	11.43	11.46	11.67
LIXF	Low	7.44	11.22	11.28	11.38	11.43	11.46	11.67
Advertising	high	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
Auventishing	Low	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
EB	high	40.971	40.971	40.971	40.971	40.971	40.971	40.971
	Low	40.971	40.971	40.971	40.971	40.971	40.971	40.971
NCO	high	40000	40000	40000	40000	40000	40000	40000
NCO	Low	30000	30000	30000	30000	30000	30000	30000
тѕс	high	0.7	0.7	0.7	0.7	0.7	0.7	0.7
100	Low	0.7	0.7	0.7	0.7	0.7	0.7	0.7
HSDG	high	0.95	0.95	0.95	0.95	0.95	0.95	0.95
11300	Low	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Rel Pay	high	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Renay	Low	0.8	0.8	0.8	0.8	0.8	0.8	0.8
QMA	high	1883304	1883304	1883304	1883304	1883304	1883304	1883304
QIVIA	Low	1883304	1883304	1883304	1883304	1883304	1883304	1883304

D. PARAMETER INPUTS FOR TEST CASE 2

Where "Recruiters" is the only variable that is fixed. EB, NCF, and advertising are floated.

		2015	2016	2017	2018	2019	2020	2021
NCF	high	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
NCF	Low	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
UE	high	0.08	0.08	0.08	0.08	0.08	0.08	0.08
UL	Low	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Recruiters	high	3500	3500	3500	3500	3500	3500	3500
Recruiters	Low	2500	2500	2500	2500	2500	2500	2500
LRP	high	7.44	11.22	11.28	11.38	11.43	11.46	11.67
LIXF	Low	7.44	11.22	11.28	11.38	11.43	11.46	11.67
Advertising	high	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
Auventishing	Low	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264	34.8264
EB	high	40.971	40.971	40.971	40.971	40.971	40.971	40.971
	Low	40.971	40.971	40.971	40.971	40.971	40.971	40.971
NCO	high	40000	40000	40000	40000	40000	40000	40000
NCO	Low	30000	30000	30000	30000	30000	30000	30000
тѕс	high	0.85	0.85	0.85	0.85	0.85	0.85	0.85
100	Low	0.7	0.7	0.7	0.7	0.7	0.7	0.7
HSDG	high	0.95	0.95	0.95	0.95	0.95	0.95	0.95
11000	Low	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Rel Pay	high	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Renay	Low	0.8	0.8	0.8	0.8	0.8	0.8	0.8
QMA	high	1883304	1873304	1863304	1853304	1843304	1833304	1823304
QIVIA	Low	1873304	1863304	1853304	1843304	1833304	1823304	1813304

APPENDIX E. SCENARIO OF INTEREST TO N1

The original baseline scenario request for a PROM-WED run was:

For your baseline scenario we can use the

- Current program of record for Recruiting mission is about 34000, so use: 30000 40000
- Advert: \$60M so use \$40M \$100M
- EB: \$55M 80M range
- Recruiters (use Current onboard) I think they are at about 2900 so use 2500 3500
- Unemployment rate we use national rate and forecast per the Blue Chip Economic Indicators long range forecast. Which has current UE at ~5.0% so use (4.0% - 8.0%)

• Vary relative pay between .8 and 1.2 (Palmer, personal communication, 14 Sep 2016)

Following continued communication with N1, the baseline scenario transitioned into a best case, worst case, and most likely case exploration. The following scenarios originated from that request. Test Case 1 and 2, explored within the report, combines all three of these cases into one PROM-WED run.

A. BEST CASE

The Navy's best case scenario would be a low recruiting mission, no limitation on the number of recruiters in the field, and favorable economic conditions for recruiting (i.e., high unemployment rate and relative pay favoring the military versus the civilian sector). Table 17 shows the variables that this scenario focuses on. In this case, all decision variables will be optimized.

Table 17. Scenario of Interest: Best Case

Variable Type	Variable Name	Value Low	Value High
Decision Variable	ariable Recruiters Float		loat
Market Factor	Recruiting Mission (NCO)	30,000 recruits	
Market Factor	Relative Pay	1.00	1.20
Market Factor	Unemployment Rate	5.5%	8.0%

B. WORST CASE

The Navy's worst case scenario would be a high recruiting mission, a limited number of recruiters in the field, and an economic environment that is unfavorable to recruiting (i.e., the unemployment rate is low and the relative pay favors the civilian sector). The inputs for the worst case scenario are shown in Table 18. In this case, the number of recruiters is fixed and all other decision variables will be optimized.

Table 18.	Scenario	of Interest:	Worst Case
	000110110	01 11100 000	1101010400

Variable Type	Variable Name	Value Low	Value High
Decision Variable	Recruiters	2,500 recruiters	
Market Factor	Recruiting Mission (NCO)	40,000 recruits	
Market Factor	Relative Pay	0.80	1.00
Market Factor	Unemployment Rate	4.0%	5.5%

C. MOST LIKELY

The most likely scenario that the Navy will face is a moderate recruiting mission, a limited range of available recruiters, and a balanced economic situation that naturally fluctuates between favorable and unfavorable conditions for recruiting. Table 19 shows the input variables for this scenario, where number of recruiters is fixed and tested over a range of values. All other decision variables will be optimized.

Table 19. Scenario of Interest: Most Likely

Variable Type	Variable Name	Value Low	Value High
Decision Variable	Recruiters	2,500 recruiters	3,000
			recruiters
Market Factor	Recruiting Mission (NCO)	35,000 recruits	
Market Factor	Relative Pay	0.80	1.20
Market Factor	Unemployment Rate	4.5%	6.5%

APPENDIX F. DISTRIBUTIONS

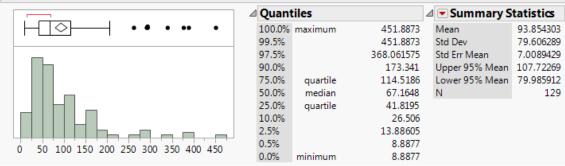
A. FY 2017 DISTRIBUTIONS FOR TEST CASE 1

 Distributions 							
A vertising							
	⊿ Quantiles		Summary Statistic				
	100.0% maximum 99.5% 97.5% 90.0% quartile 50.0% median 25.0% quartile 10.0% 2.5% 0.5% minimum	323.6418 323.6418 278.0274 120.9422 73.9048 39.7348 22.92 13.8271 7.61005 6.5819 6.5819	Mean Std Dev Std Err Mean Upper 95% Mean Lower 95% Mean N	58.118597 56.188302 4.9471041 67.907288 48.329906 129			
⊿▼EB							
	✓ Quantiles 100.0% maximum	427.2072	✓ Summary S Mean	76.716542			
0 50 100 150 200 250 300 350 400 450	99.5% 97.5% 90.0% 75.0% quartile 50.0% median 25.0% quartile 10.0% 2.5% 0.5% 0.0% minimum	427.2072 366.996125 159.6437 97.5543 52.4499 30.2544 18.2518 10.0453 8.6882 8.6882	Std Dev Std Err Mean Upper 95% Mean Lower 95% Mean N	74.168552 6.5301769 89.637612 63.795471 129			

B. FY 2017 DISTRIBUTIONS FOR TEST CASE 2

Distributions Advertising **⊿** Quantiles Summary Statistics \neg 100.0% maximum 71.101741 \vdash 342.3389 Mean 99.5% 342.3389 Std Dev 60.307798 97.5% 278.834575 Std Err Mean 5.3098056 90.0% Upper 95% Mean 81.608099 131.319 75.0% quartile 86.7565 Lower 95% Mean 60.595384 50.0% median 50.8824 N 129 31.68145 25.0% quartile 10.0% 20.0803 2.5% 10.519725 0.5% 6.7331 Ó 50 100 150 200 250 300 350 0.0% minimum 6.7331

⊿ **▼ EB**



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